PROJECT COMPLETION REPORT

ECOLOGY OF BENTHIC INSECTS IN RELATION TO WATERSHED MANAGEMENT STRATEGIES ON THE SILVER CREEK STUDY AREA, IDAHO

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by

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INTRODUCTION

The Silver Creek experimental watersheds are represented by six relatively small (0.4-0.8 mi^2), pristine drainages. They are scheduled to receive different logging-related treatments to measure the effects of logging practices on the physical and biotic features of the drainages for the purposes of minimizing the effects of sedimentation, excessive runoff, and other physical disturbances. This report represents the second of two studies conducted as cooperative agreements with the U. S. Forest Service to evaluate the prelogging and logging activities on benthic insects and associated stream environment. The first phase of the study was conducted during 1973 and 1974 (Brusven and Hart, 1975). The results of that study provided background information on the insect communities and associated physical conditions in the streams prior to treatment. This report encompasses the time period of 1975 through 1976.

Weather and climate tend to influence in a major way between-year differences in sedimentation, hydrology, organic loading, slumping, and other physical disturbances occurring naturally in the watersheds. The study of 1973 and 1974 coupled with this study permits a reasonable time period to evaluate inherent variability of benthic insects among intensive study sites and streams within the Silver Creek drainage. Biological information on benthic insects and 10 or more years of physical data taken by the U. S. Forest Service provides a basis for evaluating various logging treatments in the six experimental watersheds.

The objectives of this phase of the study include: 1) evaluate the impact of sediment dams and natural debris blockages as mechanisms of obstructing the colonization cycle of insects; 2) determine the effects of sediment removal from debris dams on downstream insect communities;

3) evaluate the effect of organic loading on insect communities; and, 4) determine the effects of helicopter logging on insect communities in lower and middle reaches of Control Creek. Considerable insight was obtained concerning objectives 1 through 3, however, objective 4 was not accomplished because of inadvertent delays in logging Control Creek. Logging was not initiated until late 1976 after the summer field season had been completed.

EXPERIMENTAL WATERSHEDS

During the initial study of 1973 and 1974 reported by Brusven and Hart (1975), a prelogging inventory was conducted on six experimental watersheds in the Silver Creek drainage which included Control, Cabin, Ditch, Eggers, D, and C Creeks. The experimental watersheds selected for continued investigation during the current study are Control, Ditch and Eggers Creeks (Fig. 1). These creeks were selected because of the proposed sequence of treatments, plus inherent physical features of the drainages that contribute to understanding problems relating to flow, sedimentation, and stream blockages on benthic insects. Control Creek has been proposed for helicopter logging using the clear-cut method (Fig. 2).

The tributaries investigated are moderate to high gradient and range from 0.4 to 0.8 square miles in area. Mean annual sediment yield ranges from 4.5 cubic yards per square mile on Control Creek to 33.8 cubic yards per square mile in Ditch Creek which has a low standard road in the drainage. Each watershed is monitored for sediment yield, discharge, precipitation and water chemistry by the USDA Forest Service. A vertical face, sediment debris dam has been constructed on the lower third of each of these drainages to trap sediments.

The stream channels are small, ranging from less than 0.5 meters in width to slightly greater than 1.0 meter in the lower reaches of most streams. Water depth ranges from several inches during spring runoff to less than one inch during low summer flow. A considerable number of natural obstructions occur in the stream channels in the form of logs, debris, and rocks which produce a series of vertical drops, small pools and riffles. Logs and debris lodged in the stream tend to serve as miniature blockages which retain sediments and organics thus changing the habitat conditions and

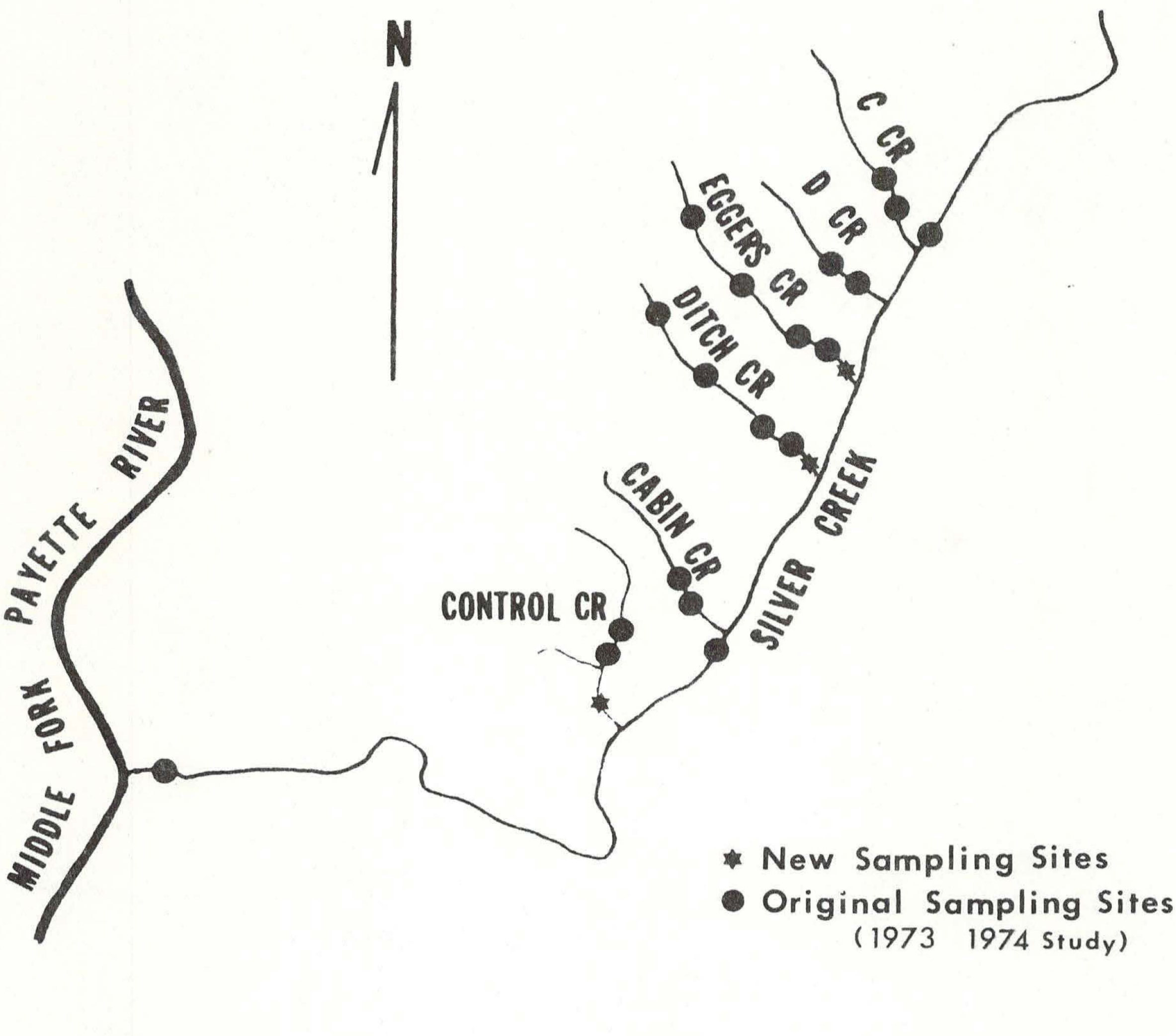

Fig. 1. Silver Creek drainage with experimental watersheds and intensive site locations.

Fig. 2. Control Creek watershed and proposed clearcut logging sections.

productivity of the streams from year to year commensurate with unusual hydrological events.

MATERIALS AND METHODS

Sediment and Flow

Sediment yield, discharge, and precipitation were monitored for each of the watersheds by the USDA Forest Service. Discharge and precipitation recording devices and a sediment catch basin are located in the lower reach of each of the watersheds. Displaced sediment is trapped within a sediment debris basin consisting of a vertical face wooden dam and an upstream pool. Sediment accumulations are measured annually; with the advent of spring runoff, the sediment is released from the dam. University of Idaho personnel were not involved in the measurement of annual discharge and sediment yield; however, USFS data were made available to aid in establishing relationships of benthic insects with various logging treatments.

Site Selection and Channel Mapping

Site selection and channel mapping were essentially similar to the methods reported by Brusven and Hart (1975). The two principal sites established during the earlier study were maintained for historical purposes. An additional site was established below the debris dam in each of the three streams of Control, Ditch and Eggers Creeks. These sites were located from 40 to 80 meters below the debris dams and were established for the purpose of measuring the effects of spring sediment flushing operations on the insect populations and to compare insect communities above and below the sediment basins. Each site was divided into three, 5 m sections. Each subsection was scaled and mapped with respect to channel configuration, surface sediments and debris locations.

Five to six transects were established across the subsections of each

site below the debris dams for the purpose of measuring changes in profile characteristics before and after sediment releases.

Surface Sediment Analysis

A surface sediment classification similar to that described by Brusven and Hart (1975) was used to characterize each intensive study site (Tables 1 and 2). The sediment characteristics of dominant substrate type, degree of embeddedness of cobbles within the sediment, and the size of the sediment around the cobbles were used to express surface sediment conditions. The site maps were computed on the basis of percent composition of predominant substrate types and reflect time-related changes between seasons and years.

Table 1. Surface sediment rank classification (modified from Sandine, 1974).

Class	Description
1	Particulate organic matter--detritus
2	less than 1.5 mm in diameter (1/16 in)--sand
3	1.5 - 6.4 mm in diameter (1/16 - 1/4 in)--course sand
4	6.4 - 25.4 mm in diameter (1/4 - 1 in)--small pebble
5	25.4 - 63.5 mm in diameter (1 - 2 1/2 in)--large pebble
6	63.5 - 127.0 mm in diameter (2 1/2 - 5 in)--small cobble
7	127.0 - 254.0 mm in diameter (6 - 10 in)--large cobble
8	greater than 254.0 mm in diameter (10 in)--boulder

Table 2. Cobble imbeddedness rank classification (Brusven and Hart, 1975).

Class	Description
1	nearly 100% imbedded (heavy)
2	75% imbedded (moderate)
3	50% imbedded (intermediate)
4	25% imbedded (light)
5	unimbedded

Benthic Insect Sampling

A Surber Bottom Sampler (1 ft^2) was used for sampling benthic insects. Two benthos samples were taken in each of the 5 m subsections of the sites above and below the catch basins. This sampling frequency differs from the earlier study where a single bottom sample was taken from each of the subsections. In the current study one sample was taken from each of the two dominant substrate types within each subsection. If one substrate type prevailed over the large majority of the area, then both samples were taken from that substrate type. Because the streams are very small and the subsections within the channel are often less than 0.3 m wide, it is difficult to precisely take a sample within the confines of a specific substrate type. Therefore, the person sampling had to be discriminate in the placement of the bottom sampler. Bottom samples were taken in May prior to the release of sediment from catch basins and during June and August.

In addition to the bottom samples taken within the subsections of the intensive study sites, subjective samples were taken in areas where large accumulations of organic matter were apparent. These samples were

taken for the purpose of determining the effects of organic loading in the stream channel on the insect diversity, abundance and distribution. Because areas largely covered with organics were generally small in size, it was necessary to subjectively select these locations rather than using a more objective randomization technique within the mosaic character of the stream channel.

In conjunction with insect bottom samples, physical characteristics of each site reflecting the microenvironment of insects were also noted and recorded. These conditions represented water depth (taken as the mean depth within the bottom sampler perimeter), water velocity (recorded as the average of 3 measurements of time of travel of a small cork over a prescribed distance) and the nature of the substrate within the perimeter of the sampler (described as dominant substrate, level of cobble imbeddedness, and the nature of sediments surrounding the cobble). The water was too shallow in most cases to use conventional current meters.

All benthic samples were placed in collecting jars partially filled with 70% ethanol and returned to the laboratory for sorting and analysis.

Insect Drift

Insect drift was taken at three locations on Control and Eggers Creeks for the purpose of evaluating sediment debris dams as ecological blockages in the colonization of stream insects. Drift nets measuring 15 x 30 cm in size, equipped with nylon organdy bags, having a mesh size of approximately 230 microns, were placed approximately 20 m above the debris dam, at the outflow of the debris dam, and in the flume approximate 20 m below the debris dam. At each location the entire flow of the stream was channeled through the drift nets giving a complete and absolute measure of drift for a specific segment of time. One-hour drift samples were taken four times

during a 24-hour period in July and August of 1975 and August 1976. These time periods coincide with periods of known inactivity and activity reflective of diel cycles of many of the benthic invertebrates in streams.

Insect-Substrate Relationships and Community Analysis

Insect-substrate relationships were determined by establishing relationships of key insect species with their microenvironment. Benthic insect samples were analyzed for standing crop, number of species, species diversity, phenology and community similarity. Species diversity and redundancy values were calculated using the Shannon-Weaver Diversity Index of Patten (1962). Species diversity and redundancy were calculated for each sample and for each stream from combined samples for each sampling date. Chironomid midges were not included in the species diversity analysis because they are largely unidentifiable to species and can produce large variations in the sensitivity of the diversity index.

Species composition, species diversity and redundancy were graphed to reflect changes in the benthic insect community resulting from natural changes in the physical environment in the streams within and between years of 1975 and 1976.

A computer program modified from Davies (1971) was used to generate a community similarity matrix based on a pairwise comparison of benthic insect communities for both years. The assumption was made that the species found in any stream on a sample date constituted the community present at that point in time. Data was in the bionary notation using 1 for presence of a species and 0 for absence. A Jaccard coefficient of similarity (Kaesler and Cairns, 1972) was computed for each community comparison. A single linkage cluster analysis subroutine was used on the similarity matrices to show relationships among the insect communities of the various streams on

different sampling dates and between the two years. The cluster analysis was presented in the form of dendrograms to show the degree of similarity among and within clustered communities.

RESULTS

The following results represent new data relevant to the objectives of the present study, plus historical information pertinent to interpreting the ecology of benthic insects. The historical data, particularly the physical features of the experimental watersheds, are the product of studies of the U. S. Forest Service dating from the 1960's along with current studies by the Department of Entomology, University of Idaho. The inclusion of these data is to provide continuity, integration and interpretation of benthic insect distribution, abundance and productivity in relation to future logging-related treatments.

Physical Characteristics

Morphometric Characteristics of Experimental Watersheds

For purposes of comparison, morphometric features of Control, Eggers and Ditch Creeks are given in Table 3. The Control Creek Drainage occupies the largest area (0.78 sq mi) and has the lowest mean annual sediment yield (4.5 cu yd/mi^2/yr). In contrast, Ditch Creek occupies the smallest area (0.41 sq mi) but the highest mean annual sediment yield (33.8 yd cu/mi^2/yr). Eggers Creek, which has the highest mean channel gradient occupies essentially an intermediate position with regard to area and mean annual sediment yield. The Ditch Creek watershed contains a 37-year-old low standard road which contributes an appreciable amount of the sediment to the stream channel. All drainages are well forested and essentially pristine with the exception of Ditch Creek.

Table 3. Morphometric features of Control, Eggers and Ditch Creeks for water years 1966-1972 (from Megahan, 1972).

Drainage	Area	Elevation[2]	Dominant aspect	Mean channel gradient[3]	Mean annual sediment yield	Standard deviation
	Mi^2	Feet		Percent	$Yd^3/mi^2/yr$	$Yd^3/mi^2/yr$
Control	0.78	5,240	SE	15.2	4.5	3.8
Eggers	0.50	5,685	SE	22.0	16.0	13.0
Ditch[1]	0.41	5,350	SE	20.8	33.8	30.4

[1] The Ditch Creek watershed contains a 37-year-old low standard road.
[2] (Maximum elevation - minimum elevation)/2.
[3] (Total relief/length main channel to the upper ridge) 100.

Precipitation and Discharge

Annual precipitation has been recorded for several of the experimental watersheds. Control Creek has been intensively studied during the last two years, and the annual precipitation for this drainage for water years 1968-1974 is in Table 4. Precipitation data has been gathered by USFS subsequent to 1974 but has not been analyzed, therefore, not available for inclusion in this report. Considerable variation existed between years ranging from 27.99 to 43.67 inches at the middle station on Control. It is significant to note that precipitation for the lower reach of Control Creek was approximately 1/2 to 1 inch less than the precipitation recorded at the middle reach of the drainage.

The mean annual hydrograph for Control, Ditch and Eggers Creeks reflects peak discharges during the months of March, April and May (Fig. 3). Eggers Creek, in spite of its smaller area, has a much larger peak discharge

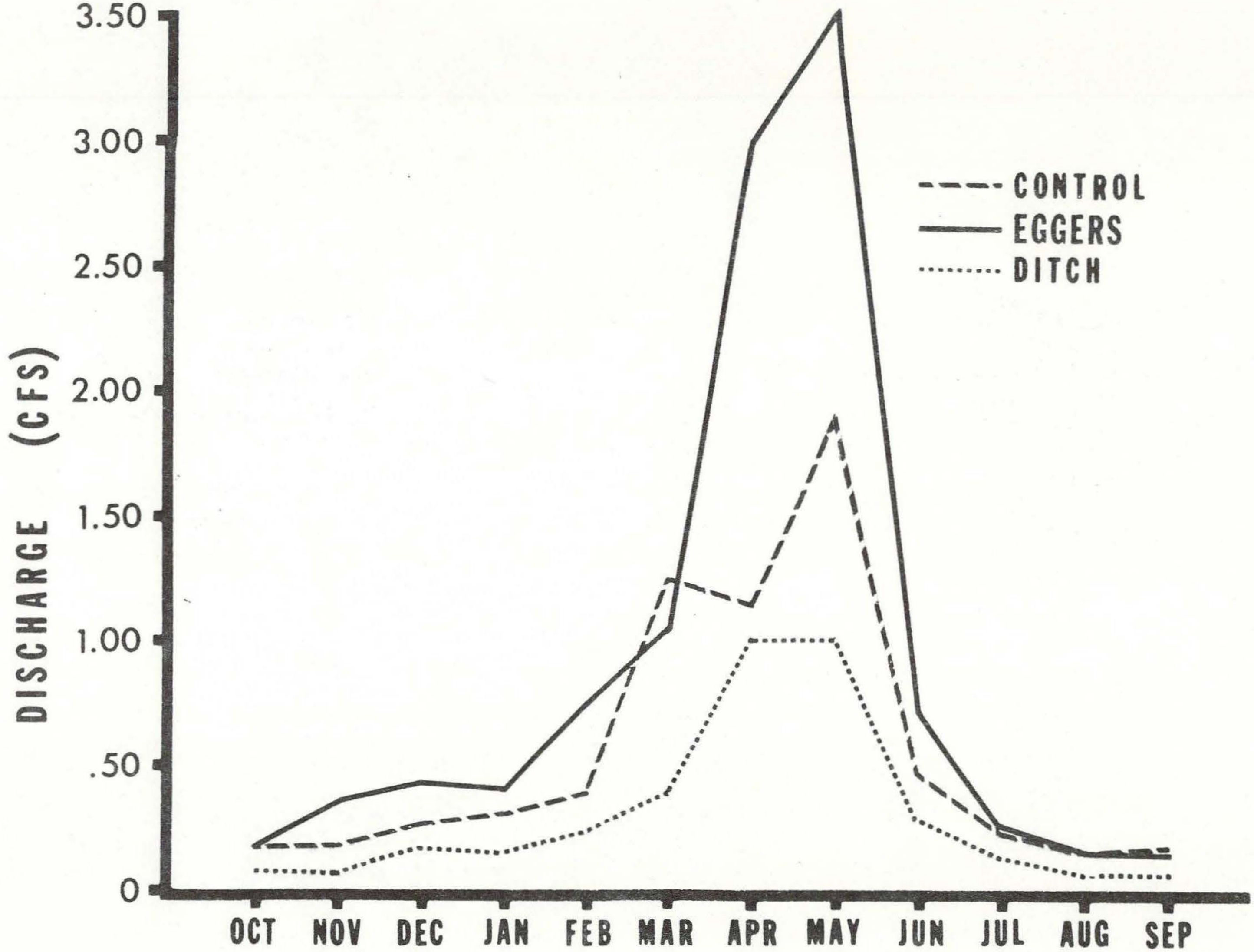

Fig. 3. Mean annual hydrograph for Control, Ditch and Eggers Creeks (3-10 years USDA Forest Service data).

than Control Creek. Ditch Creek has the lowest discharge of the three streams for all months of the year. Discharge for Control Creek occupies an intermediate position in the comparative hydrograph analysis and is bimodal; the highest peak discharge occurs in May.

Table 4. Annual precipitation (inches) at two stations on Control Creek study area for water years 1968-1974 (USDA Forest Service data).

Water Year	Lower Control	Middle Control
1968	29.42	30.92
1969	30.92	31.24
1970	39.43	40.37
1971	39.68	39.90
1972	35.53	35.31
1973	25.80	27.99
1974	42.62	43.67

Sedimentation and Channel Obstructions

The number of obstructions and average sediment volume per unit of stream channel length are given in Table 5, the frequency of occurrence of obstruction types in Table 6. These data reflect average values for all seven experimental watersheds in the Silver Creek drainage. When comparing the number of obstructions per unit length of channel among Control, Ditch and Eggers Creeks in 1973, it is apparent that Ditch Creek has the highest number of obstructions followed by Eggers and Control Creeks, respectively. There are relatively large between-year differences in number of obstructions; over a 20 percent reduction of obstructions is noted for Ditch Creek during 1973 and 1974.

The average sediment stored in these three streams was much more variable than the number of obstructions. Ditch Creek stored the greatest amount of sediment, Control Creek the least in 1973. Sediment storage in

Control Creek in 1974 increased by over 60 percent; Ditch Creek had a small increase while Eggers Creek decreased by 12 percent.

Table 5. Volume of sediment stored behind obstructions, 1973 and 1974. (From Megahan 1976 - with permission). *=drainages under current investigation.

Drainage name	Number of obstructions per 30 meters (100 feet) of channel		Average sediment volume/ obstruction		Average sediment volume/ 30 meters (100 feet) of channels		Total sediment behind obstructions/total channel length	
	1973	1974	1973	1974	1973	1974	1973	1974
			m^3 (ft^3)		m^3 (ft^3)		m^3 (ft^3)	
C	4.5	3.2	0.52 (18.2)	0.60 (21.2	2.34 (82.7)	1.93 (68.1	729 (25,662)	600 (21,215)
D	6.4	3.6	9.36 (12.7	0.46 (16.1)	2.31 (81.7	1.62 (57.4)	415 (14,667)	292 (10,304)
Eggers*	3.2	2.5	0.20 (7.0)	0.20 (7.0)	0.62 (22.0)	0.55 (19.4)	118 (4,182)	104 (3,688)
Ditch*	3.8	3.1	0.18 (6.5)	0.25 (8.7)	0.79 (24.9)	0.78 (27.7)	67 (2,366)	75 (2,633)
Cabin	3.5	2.5	0.18 (6.2)	0.25 (8.9)	0.62 (21.8)	0.63 (22.3)	104 (3,683)	107 (3,768)
Control*	2.9	2.8	0.12 (4.4	0.20 (7.2)	0.35 (12.5)	0.57 (20.2)	78 (2,772)	127 (4,480)
K-1	3.6	4.3	0.18 (6.5)	0.29 (10.1)	0.66 (23.3)	1.22 (43.1)	21 (738)	39 (1,365)
Average	3.9	3.0	0.29 (10.2)	0.35 (12.2)	1.13 (40.0)	1.04 (36.7)	219 (7,739)	192 (6,779)

Table 6. Frequency of occurrence of obstructions by type, 1973 and 1974 for seven experimental watersheds. (From Megahan 1976 - with permission).

Obstructions	Total number		Percent	
	1973	1974	1973	1974
Logs	133	123	34.5	41.8
Debris [a/]	107	121	27.8	41.1
Rocks	94	46	24.4	15.6
Roots	49	2	12.7	9.7
Stumps	2	2	0.6	0.8
Total	386	294	100.0	100.0

The mean percent streambed covered by the various substrate classes for Sites 1 and 2 of Cabin, Ditch and Eggers Creeks are given in Table 7. Data from an earlier study by Brusven and Hart (1975) for the years 1973 and 1974 are included for comparison purposes. It should be pointed out that during the present study, benthos samples were taken only from Site 2 rather than both Sites 1 and 2 as in the earlier study. This was to accommodate expansion of benthic sampling to a new site below the debris dam referred to in this report as Site 3. The dominant surface sediments at all sites were represented as classes 2 through 5 (grain size <1.5 mm to 63.5 mm in diameter). Surface organics were sparse and represented by less than 5 percent of the total surface area of the sites during most dates sampled; sediment grain sizes larger than 63.5 mm were also sparse, representing less than 5 percent of the total surface area in most instances. It is noted, however, that during 1976, Eggers Creek had a much greater predominance of small and large cobbles (sediment classes 6 and 7).

Table 7. Mean % streambed covered by substrate classes within Sites 1 and 2 of Cabin, Ditch and Eggers Creeks, 1973-1976.

		Mean % Substrate Class						
Stream	Date	1	2	3	4	5	6	7
Control Cr.	June 73	15	25	27	31	-	-	-
	Aug. 73	9	43	38	10	-	-	-
	June 74	8	27	21	29	13		2
	Aug. 74	4	21	20	17	34	-	4
	July 75	5	22	13	50	9	-	3
	Aug. 75	3	28	17	33	15	-	4
	May 76	0	24	8	33	35	-	-
	June 75	1	26	13	21	38	<1	-
	Aug. 76	2	27	13	19	39	-	-
Ditch Cr.	June 73	3	50	35	12	-	-	-
	Aug. 73	-	75	25	-	-	-	-
	June 74	1	19	26	49	4	-	1
	Aug. 74	6	7	20	5	54	-	8
	July 75	0	48	9	21	27	-	-
	Aug. 75	0	51	4	40	5	-	-
	May 76	-	7	8	59	21	5	-
	June 76	-	10	9	52	24	5	-
	Aug. 76	-	28	18	34	20	-	-
Eggers Cr.	June 73	6	52	28	3	5	-	6
	Aug. 73	5	75	14	-	-	-	6
	June 74	1	47	18	14	11	-	9
	Aug. 74	-	26	45	3	14	-	12
	July 75	0	55	10	17	11	-	7
	Aug. 75	0	41	35	9	15	-	-
	May 76	-	17	5	27	13	23	15
	June 76	-	19	12	20	11	22	16
	Aug. 76	-	33	4	15	15	16	17

The combined average sediment classes of Site 1 and 2 showed the greatest variation between dates and years occurred in Ditch Creek. The basic trend between dates for the three streams was that a greater percentage of sands prevailed during late summer than early fall. In a more specific analysis, percent composition of surface sediments from three stations on Control, Ditch and Eggers Creeks for 1975 and 1976 are given in Tables 8-10. Station 3 is a new station and located below the debris dam. Its establishment was to provide information on changes in surface sediment composition prior to and after sediment releases from sediment dams.

Organics (substrate class 1) were minimumly represented in the Control Creek sites during 1975 and 1976 and essentially absent in Ditch and Eggers Creek sites. Sands (substrate class 2) made up a noticeably greater percentage of the surface sediments in Site 3 than the two sites above the debris dam in Control Creek in 1975. Between site differences in sand composition were not so apparent in 1976. Large pebbles (substrate class 5) were much more prevalent than during the same period in 1975. Large cobbles (substrate class 7) were only detected at Site 2 in 1975.

Ditch Creek, like Control Creek, reflected a preponderance of sands at Station 3 below the debris dam. This condition was also evidenced at Stations 1 and 2 during the same time period. Substrate classes 2 to 5 (<1.5 to 63.5 mm) collectively represented over 95 percent of the surface sediments; substrate class 4 (6.4 to 25.4 mm diameter) was the dominant class. Sands (substrate class 2) were much less prevalent as the dominant substrate type in 1976 than 1975; the highest recorded sand composition in 1976 was during August when they represented 26.6 to 30.0 percent of the surface sediment for the three sites. Cobbles were sparsely represented at Stations 1 and 2 during May and June and undetectable in August, 1976.

Eggers Creek shared many of the sediment composition trends of Ditch Creek in that organics (substrate class 1) were essentially undectable and surface sands (substrate class 2) and small cobbles (class 5) were more prevalent in 1975 than 1976. Sand (substrate class 2) was the predominant substrate type in 1975 at Station 3 below the debris dam, whereas substrate class 5 (cobble) was most prevalent in 1976. Large variations among stations and dates is an expected event because of oftentimes local and extreme hydrological events that change stream channel conditions.

Table 8. Percent composition of surface sediments from three stations on Control Creek, 1975-1976.

			Substrate Class							
Creek	Date	Sta-tion	1	2	3	4	5	6	7	8
Control	July 1975	I	5.0	21.7	8.3	55.0	10.0	0.0	0.0	0.0
		II	0.0	23.3	16.7	45.0	8.3	0.0	6.7	0.0
		III	0.0	65.0	31.7	3.4	0.0	0.0	0.0	0.0
	Aug. 1975	I	6.7	16.7	26.7	50.0	0.0	0.0	0.0	0.0
		II	0.0	40.0	5.0	16.7	31.7	0.0	6.7	0.0
		III	0.0	53.3	33.3	13.4	0.0	0.0	0.0	0.0
	May 1976	I	0.0	21.5	4.0	35.6	38.9	0.0	0.0	0.0
		II	0.0	26.4	13.2	30.0	31.4	0.0	0.0	0.0
		III	0.0	29.0	17.6	28.7	24.8	0.0	0.0	0.0
	June 1976	I	1.8	28.2	5.6	32.7	31.7	0.0	0.0	0.0
		II	0.0	23.9	19.3	9.9	45.8	0.6	0.0	0.0
		III	0.0	32.0	59.4	6.9	1.8	0.0	0.0	0.0
	Aug. 1976	I	1.7	30.1	6.0	31.2	31.0	0.0	0.0	0.0
		II	1.4	24.0	20.2	6.1	48.0	0.0	0.0	0.0
		III	0.0	30.0	69.1	0.0	0.9	0.0	0.0	0.0

Table 9. Percent composition of surface sediments from three stations on Ditch Creek, 1975-1976.

Creek	Date	Station	Substrate Class 1	2	3	4	5	6	7	8
Ditch	July 1975	I	0.0	56.7	8.3	11.7	23.4	0.0	0.0	0.0
		II	0.0	38.3	10.0	30.0	21.7	0.0	0.0	0.0
		III	0.0	66.7	5.0	6.7	18.3	3.4	0.0	0.0
	Aug. 1975	I	0.0	73.3	3.3	16.7	6.7	0.0	0.0	0.0
		II	0.0	28.3	5.0	63.3	3.3	0.0	0.0	0.0
		III	0.0	70.0	13.3	0.0	16.7	0.0	0.0	0.0
	May 1976	I	0.0	10.5	2.6	71.0	10.2	5.7	0.0	0.0
		II	0.0	3.5	12.6	46.2	33.3	4.3	0.0	0.0
		III	0.0	5.5	1.1	64.8	28.6	0.0	0.0	0.0
	June 1976	I	0.0	7.1	6.1	69.0	10.7	7.1	0.0	0.0
		II	0.0	13.3	12.0	34.0	37.1	3.5	0.0	0.0
		III	0.0	11.8	11.6	60.2	16.4	0.0	0.0	0.0
	Aug. 1976	I	0.0	29.5	26.9	30.5	13.1	0.0	0.0	0.0
		II	0.0	26.6	10.6	38.2	24.6	0.0	0.0	0.0
		III	0.0	30.0	24.4	31.2	14.4	0.0	0.0	0.0

Table 10. Percent composition of surface sediments from three stations on Eggers Creek, 1975-1976.

			Substrate Class							
Creek	Date	Station	1	2	3	4	5	6	7	8
Eggers	July 1975	I	0.0	66.7	3.3	20.4	3.3	0.0	6.7	0.0
		II	0.0	43.3	16.7	13.3	20.0	0.0	6.7	0.0
		III	0.0	50.0	15.0	8.3	15.0	0.0	3.3	8.3
	Aug. 1975	I	0.0	31.7	60.0	5.0	3.3	0.0	0.0	0.0
		II	0.0	50.0	10.0	13.3	26.7	0.0	0.0	0.0
		III	0.0	43.3	23.3	20.0	13.3	0.0	0.0	0.0
	May 1976	I	0.0	13.5	10.8	24.9	8.1	13.3	14.1	0.0
		II	0.0	14.8	0.0	26.3	13.6	31.7	0.0	0.0
		III	0.0	1.4	8.4	0.0	90.2	0.0	0.0	0.0
	June 1976	I	0.0	21.7	8.4	20.6	6.2	14.3	13.3	0.0
		II	0.0	8.7	15.8	17.1	28.1	30.3	0.0	0.0
		III	0.0	13.0	22.5	1.1	63.4	0.0	0.0	0.0
	Aug. 1976	I	0.0	29.4	0.0	17.9	6.3	6.7	15.1	0.0
		II	0.0	30.9	0.7	8.5	17.9	41.9	0.0	0.0
		III	0.0	14.4	20.1	1.3	64.3	0.0	0.0	0.0

Stream Channel Profiles

Multiple transect profiles taken at Stations 2 and 3 during May prior to the release of sediment and mid-June after sediment release on Control, Ditch and Eggers Creeks are given in Tables 11-13. As would be expected, the watered perimeter of each transect decreased from May to June because of postrunoff conditions. The average percent change of the profiles on Control Creek for May and June was essentially zero. Because of local, hydrological forces operating within each subsection of a station, it is not unexpected that differences for a given profile existed between dates as indicated in Table 11.

Ditch Creek differed from Control Creek in that the percent total depth change of all transects reflected a 2 percent degradation between the months of May and June indicating a scour effect. Only transect 6 reflected an appreciable aggregation condition.

Average profile conditions for Eggers Creek changed little between May and June (Table 13). An average transect change of 1.4 percent aggregation was noted. It is significant to point out that the actual stream width at each transect point did not change appreciably as in the cases of Control and Ditch Creeks. While transect 1 decreased markedly the remaining 4 transects changed little in stream width.

Table 11. Average transect profiles and stream widths from three subsections on Site III below sediment debris dam on Control Creek, before (May 12) and after (June 16) sediment release from Debris dam, 1976.

		May 12		June 16		
Stream Subsection	Transect	Ave. Depth(in)	Stream Width(in)	Ave. Depth(in)	Stream Width(in)	Depth Ratio Change
A	1	25.6	63	26.9	44	1:1.05
	2	16.7	39	17.4	35	1:1.04
	3	16.4	47	14.7	43	1.1:1
B	4	13.1	95	14.0	58	1:1.07
C	5	19.1	42	18.7	30	1.02:1
	6	28.8	53	28.1	44	1.02:1
	Total	119.7		119.8		1:1

% total depth change - 0.0%

Table 12. Average transect profiles and stream widths on Site III below sediment debris dam on Ditch Creek before (May 12) and after (June 16) sediment release from Debris dam, 1976.

		May 12		June 16		
Stream Subsection	Transect	Ave. Depth(in)	Stream Width(in)	Ave. Depth(in)	Stream Width(in)	Depth Ratio Change
A	1	19.0	26	20.3	23	1:1.07
	2	21.8	25	21.6	25	1.01:1
B	3	24.9	48	26.5	45	1:1.06
	4	14.2	34	15.0	29	1:1.06
C	5	18.0	34	19.3	27	1:1.07
	6	19.6	72	17.2	36	1.14:1
	Total	117.5		119.9		

% total depth change - 2.0% degradation

Table 13. Average transect profiles and stream widths on Site III below the sediment debris dam on Eggers Creek before (May 12) and after (June 16) sediment release from Debris dam, 1976.

		May 12		June 16		
Stream Subsection	Transect	Ave. Depth(in)	Stream Width(in)	Ave. Depth(in)	Stream Width(in)	Depth Ratio Change
A	1	14.7	48	15.4	27	1:1.05
	2	26.1	27	24.8	27	1.05:1
B	3	23.3	59	22.4	59	1.04:1
C	4	21.0	42	21.1	43	1:1
	5	18.1	65	18.1	67	1:1
	Total	103.2		101.8		

% total depth change - 1.4% aggregation

Benthic Insect Relationships

Benthic Insect Community

An updated checklist of the insect fauna collected from the experimental watersheds in the Silver Creek drainage is given in Appendix A. This checklist includes species reported in an earlier report by Brusven and Hart (1975) as well as new species recovered subsequent to that time from Control, Ditch and Eggers Creeks. Nearly 100 species of insects exclusive of Chironomidae have been identified for the study watersheds. Five orders of insects are represented and include Ephemeroptera, Plecoptera, Trichoptera, Coleoptera and Diptera. Greater resolution on the taxonomy of Trichoptera (caddisfly) larvae is now possible with the recent work by Wiggins (1977). Several revisions at the generic level have resulted in splitting some of the earlier names given in the report by Brusven and Hart. Most of the insects represented in the collections were members of a few species. Rare species represented by a single or a few specimens taken over a period of years tends to magnify the number of species present in the drainage. The largest number of species recovered in the study watersheds are members of the orders Ephemeroptera, Trichoptera and Diptera. The number of species, density and species diversity from study Sites 2 and 3 on Control, Ditch and Eggers Creeks are presented in Table 14. Almost without exception there was a greater number of species recovered from the study site above the debris dam than below. Notable exceptions were May 1976 on Control Creek and August 1975 on Ditch Creek. The number of species exclusive of Chironomidae on a given date ranged from seven (May 1976, Site 3 - Ditch Creek) to 36 species (August 1975, Site 2 - Control Creek). Insects density was generally greater at the site above the debris dam than below; densities

Table 14. Number of species, density, species diversity and evenness in study Sites II (above Debris Dam) and III (below Debris Dam) in Control, Ditch and Eggers Creeks, 1975 and 1976. *Midges not included.

Creek	Site	Date	No species*	Density/m^2	Diversity*	Evenness*
Control	II	July 1975	32	1473	3.23	0.65
	III	"	25	592	2.98	0.67
	II	Aug. 1975	36	1643	3.14	0.61
	III	"	29	1335	3.20	0.66
	II	May 1976	24	258	3.01	0.59
	III	"	26	510	2.00	0.58
	II	June 1976	35	1395	3.38	0.64
	III	"	27	425	3.33	0.67
	II	Aug. 1976	25	417	2.87	0.60
	III	"	19	150	3.19	0.73
Ditch	II	July 1975	31	881	2.40	0.48
	III	"	24	496	2.60	0.58
	II	Aug. 1975	25	934	2.29	0.49
	III	"	34	741	3.17	0.65
	II	May 1976	22	237	3.59	0.72
	III	"	7	45	2.52	0.74
	II	June 1976	27	833	2.80	0.55
	III	"	22	247	3.23	0.70
	II	Aug. 1976	28	274	3.11	0.60
	III	"	20	247	2.55	0.73
Eggers	II	July 1975	25	745	2.63	0.57
	III	"	27	748	2.80	0.60
	II	Aug. 1975	29	1061	3.14	0.65
	III	"	28	1249	3.12	0.64
	II	May 1976	30	422	3.78	0.75
	III	"	30	346	3.94	0.78
	II	June 1976	36	1009	3.27	0.60
	III	"	28	304	3.74	0.71
	II	Aug. 1976	26	853	2.73	0.56
	III	"	20	427	2.62	0.59

usually ranged from 2 to 5 times greater at the above dam site. Diversity values for the same stations did not show similar variations. Computed diversity values generally ranged from 2.7 to 3.4 which would indicate relatively unstressed communities. Evenness values ranged from 0.55 to 0.70 suggesting a moderately even distribution among species. As a point of explanation, evenness values approaching 0 suggest a very simple community having but a single species represented.

Community similarity between above and below dam sites was 0.68 in both Control and Eggers Creeks in July 1975 and 0.63 in Control Creek and 0.78 in Eggers Creek in August 1975 (Table 15). In Ditch Creek the community similarity was 0.34 in July and 0.60 in August.

Community similarities are brought out by cluster analysis which show an overall greater similarity among sites in August and a low similarity of the Ditch Creek site below the dam in July 1975 (Fig. 4). There was little tendency for the two sites on a given stream to cluster together during July and August except for Eggers Creek.

During 1976 the dendrograms for the three watersheds had a very different clustering pattern with respect to time (Fig. 5). During May, the two sites on a given stream had closer clustering affinities to each other than sites between Streams. The May sample period occurred prior to sediment release from the dams and reflects a relatively stable overwintering community. During the June sampling period, after sediment had been released from the debris dams coefficient values were on the same order of magnitude as during the May sampling period. However, the clusted groups did not reflect a similar clustering pattern noted for May. The sites below the debris dam on Control and Ditch Creeks had the highest affinities and clustered at a 0.75 level. The Eggers Creek site below the debris dam has the least affinity to the other clustered groups (0.63). The August sample

Table 15. Jaccard coefficients of community similarity between study Sites above (II) and below (III) dams in Control, Ditch and Eggers Creeks in July and August 1975.

		Control		Ditch		Eggers	
		II	III	II	III	II	III
July							
	Control II	--	0.68	0.75	0.37	0.54	0.60
	Control III		--	0.60	0.36	0.52	0.44
	Ditch II			--	0.34	0.56	0.61
	Ditch III				--	0.36	0.34
	Eggers II					--	0.68
	Eggers III						--
August							
	Control II	--	0.63	0.61	0.63	0.67	0.60
	Control III		--	0.64	0.66	0.66	0.58
	Ditch II			--	0.60	0.74	0.61
	Ditch III				--	0.66	0.55
	Eggers II					--	0.78
	Eggers III						--

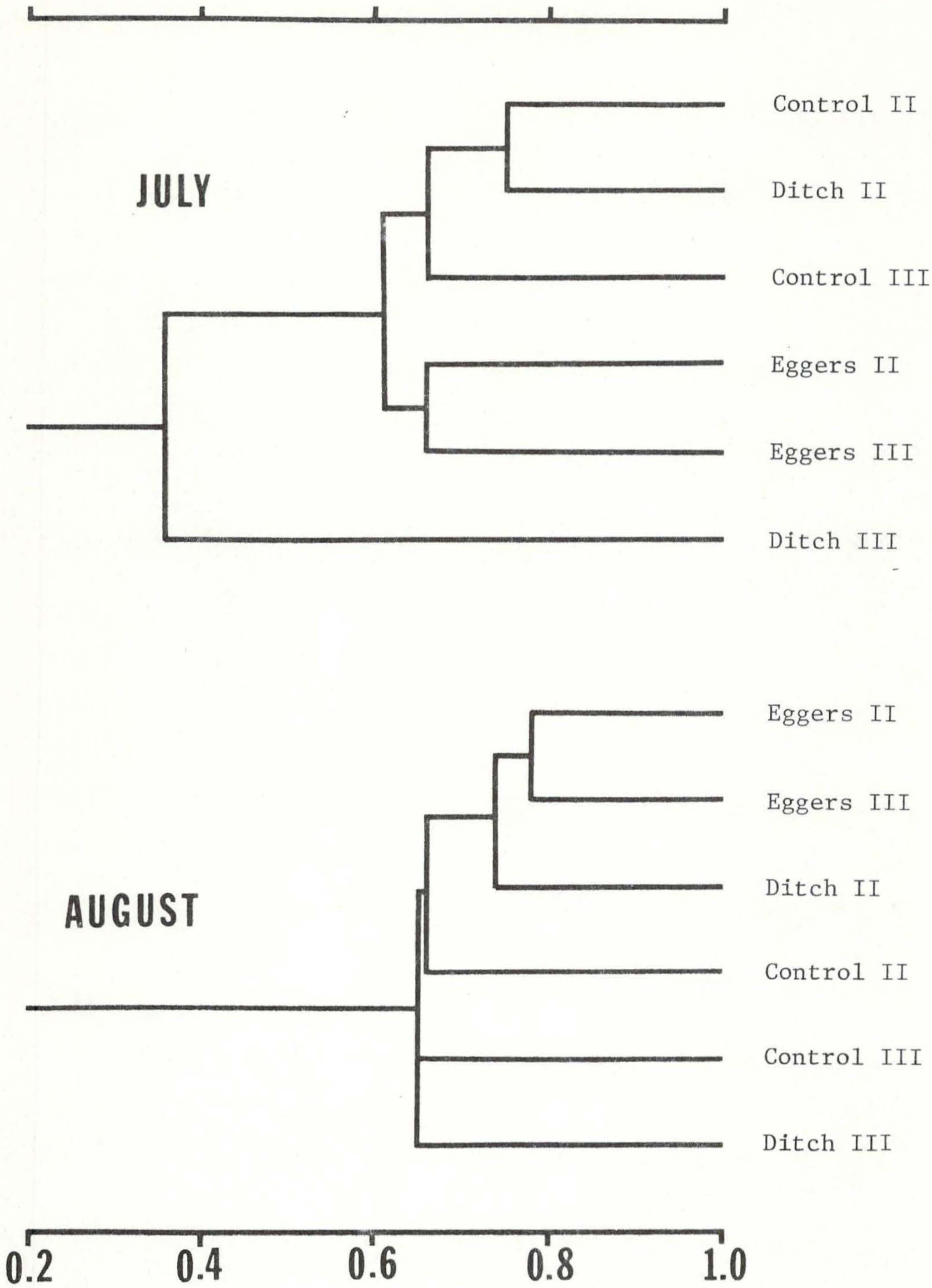

Fig. 4. Cluster analysis dendrogram of Jaccard coefficients depicting relationships among communities of Control, Ditch and Eggers Creeks in July and August, 1975.

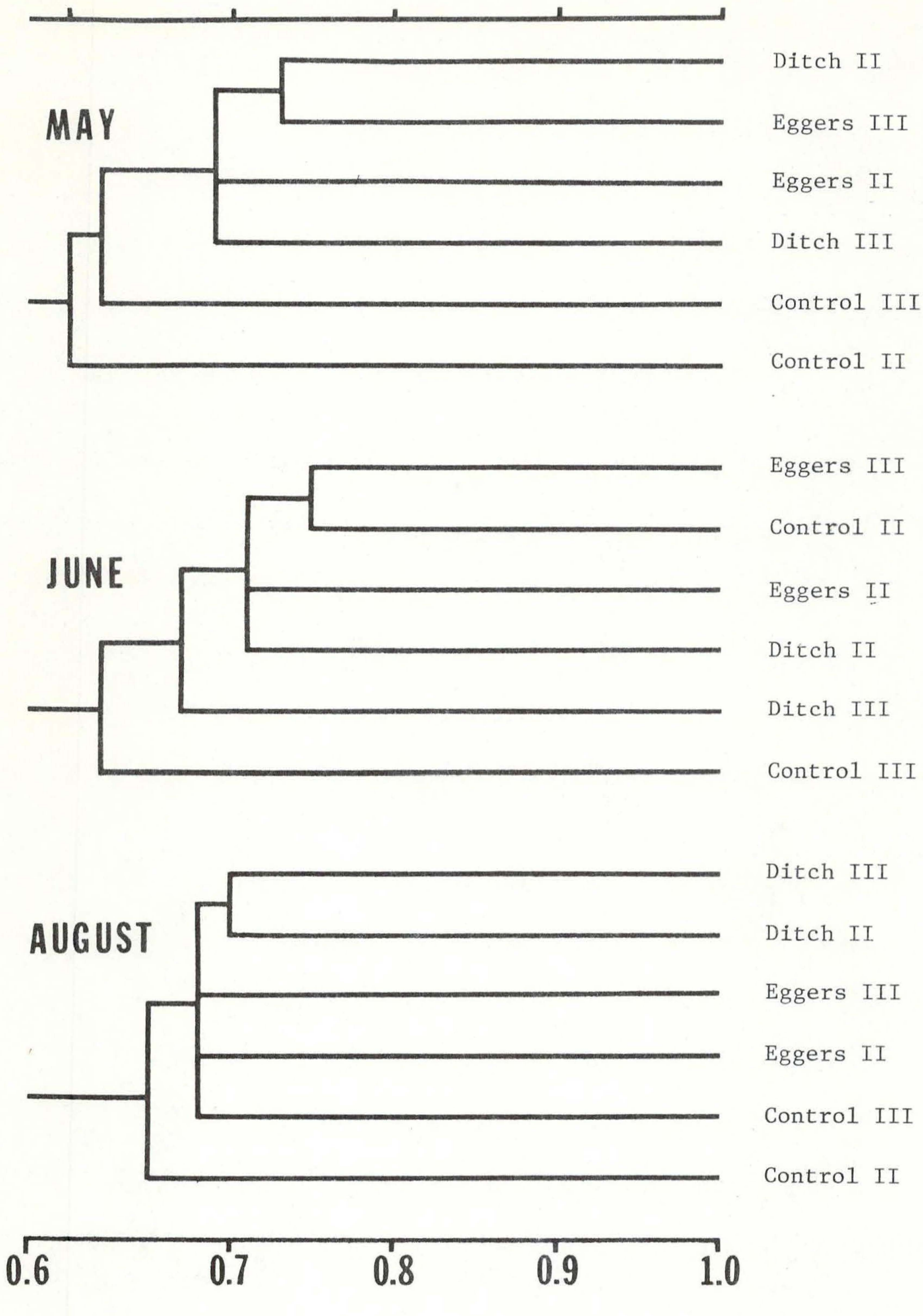

Fig. 5. Cluster analysis dendrogram of Jaccard coefficients depicting relationships among communities of Control, Ditch and Eggers Creeks in May, June and August, 1976.

reflected a very small similarity difference among the clustered groups indicating considerable similarity in community structure. Because of the small differences in coefficient values, it is difficult to generalize about affinities of the above and below dam sites for a given creek or between creeks during August.

Both site and seasonal trends are reflected for the three creeks for ordinal and species composition (Tables 16-18). Trichoptera was one of the most diverse orders from the standpoint of species in the three creeks. Mayflies had the highest densities in Control and Ditch Creek during May, stoneflies and elmid beetles prevailed in June and August. Elmid beetles were particularly prevalent at Site 2 below the dam on Ditch Creek. The Eggers Creek site above the debris dam was dominated primarily by stoneflies (principally Peltoperla) and elmid beetles (principally Heterlimnius); mayflies (principally Baetis bicaudatus) were most prevalent during May, giving way to elmid beetles in August.

Benthic Insect-Organic Debris Associations

Organic debris in the form of semi-decomposed leaves, twigs, bark and plant material, occur to some degree in all mountainous streams originating in forested areas. While the organic material did not occur in large areas, but rather in small pockets where water velocities permitted deposition, we believed it important to subjectively sample these habitats for the purpose of establishing insect community relationships. Samples were subjectively taken from two locations on each of the three streams studied. The number of species, density and diversity of insects is presented in Table 19. The average number of species represented in samples from Control and Eggers Creeks in July was 13.5. Considerably fewer species were present in Ditch Creek. While the number of species

Table 16. Percent species and percent density composition of five aquatic insect orders for May, June and August 1976, for Control, Ditch and Eggers Creeks at Site II (above sediment dam) and Site III (below sediment dam).

		12 May '76		16 June '76		4 August '76	
		% species (excluding chironomids)	% numbers (including chironomids)	% species (excluding chironomids)	% numbers (including chironomids)	% species (excluding chironomids)	% numbers (including chironomids)
CONTROL CREEK							
	Ephemeroptera	16.7	49.3	22.9	30.5	28.0	13.3
	Plecoptera	20.8	22.9	11.4	32.9	8.0	28.3
II	Trichoptera	37.5	11.1	45.7	17.7	32.0	12.4
	Diptera	20.8	7.6	11.4	5.0	16.0	5.6
	Coleoptera	4.2	9.0	8.6	13.9	16.0	40.3
	Ephemeroptera	19.2	65.6	14.8	9.7	31.6	9.5
	Plecoptera	23.1	14.0	18.5	42.6	15.8	20.2
III	Tricoptera	34.6	6.3	40.7	10.1	26.3	20.2
	Diptera	15.4	11.2	18.5	19.8	10.5	13.1
	Coleoptera	7.7	2.8	7.4	17.7	15.8	36.9
DITCH CREEK							
	Ephemeroptera	18.2	34.8	22.2	17.6	25.0	9.2
	Plecoptera	9.1	20.5	14.8	49.7	10.7	30.7
II	Trichoptera	36.3	23.5	44.4	8.8	25.0	8.5
	Diptera	27.3	10.6	11.1	4.3	25.0	9.8
	Coleoptera	9.1	10.6	7.4	19.6	14.3	41.8
	Ephemeroptera	28.6	52.0	22.7	14.5	25.0	18.1
	Plecoptera	28.6	16.0	18.2	22.5	25.0	15.9
III	Trichoptera	42.8	28.0	31.8	7.2	20.0	6.5
	Diptera	-	4.0	18.2	11.6	20.0	6.5
	Coleoptera	-	-	9.1	44.2	10.0	52.9

Table 16. (continued)

		12 May '76		16 June '76		4 August '76	
		% species (excluding chironomids)	% numbers (including chironomids)	% species (excluding chironomids)	% numbers (including chironomids)	%species (excluding chironomids)	% numbers (including chironomids)
EGGERS CREEK							
	Ephemeroptera	20.0	11.1	27.8	27.5	26.9	14.5
	Plecoptera	6.7	28.5	11.1	34.3	15.4	31.7
II	Trichoptera	36.7	15.7	36.1	7.1	26.9	4.6
	Diptera	23.3	17.9	13.9	7.1	15.4	12.8
	Coleoptera	13.3	26.8	11.1	24.0	15.4	36.3
	Ephemeroptera	33.3	56.5	28.6	31.8	25.0	18.9
	Plecoptera	13.3	16.6	17.9	14.7	25.0	10.5
III	Trichoptera	33.3	10.4	32.1	14.1	30.0	8.8
	Diptera	10.0	11.8	7.1	4.7	10.0	8.4
	Coleoptera	10.0	4.7	14.3	34.7	10.0	53.4

Table 17. Mean insect ordinal density/ft^2 for Control, Ditch and Eggers Creeks, 1976.

		12 May '76 Mean no. insects/ft^2	16 June '76 Mean no. insects/ft^2	4 August '76 Mean no insects/ft^2
CONTROL CREEK				
	Ephemeroptera	11.8	39.5	5.2
	Plecoptera	5.5	42.7	11.0
II	Trichopters	2.7	23.0	4.8
	Diptera	1.8	6.5	2.2
	Coleoptera	2.2	18.0	15.7
	Ephemeroptera	31.2	3.8	1.3
	Plecoptera	6.7	16.8	2.8
III	Trichoptera	3.0	4.0	2.8
	Diptera	5.3	7.8	1.8
	Coleoptera	1.3	7.0	5.2
DITCH CREEK				
	Ephemeroptera	7.7	13.7	2.3
	Plecoptera	4.5	38.5	7.8
II	Trichoptera	5.2	6.8	2.2
	Diptera	2.3	3.3	2.5
	Coleoptera	2.3	15.1	10.7
	Ephemeroptera	2.2	3.3	4.2
	Plecoptera	0.67	5.2	3.7
III	Trichoptera	1.2	1.7	1.5
	Diptera	0.17	2.7	1.5
	Coleoptera	-	10.2	12.2
EGGERS CREEK				
	Ephemeroptera	4.3	25.8	11.5
	Plecoptera	11.2	32.2	25.2
II	Trichoptera	6.2	6.7	3.7
	Diptera	7.0	6.7	10.2
	Coleoptera	10.5	22.5	28.8
	Ephemeroptera	18.2	9.0	7.5
	Plecoptera	5.3	4.2	4.2
III	Trichoptera	3.3	4.0	3.5
	Diptera	3.8	1.3	3.3
	Coleoptera	1.5	9.8	21.2

Table 18. Mean density of principal insect species for Control, Ditch and Eggers Creeks, 1976.

		12 May '76 Mean no. insects/ft^2	16 June '76 Mean no. insects/ft^2	4 August '76 Mean no. insects/ft^2
CONTROL CREEK				
	Cinygmula sp.	61.0	24.2	2.7
II	*B. bicaudatus*	2.2	3.2	-
	Peltoperla sp.	4.7	39.7	10.5
	Heterlimnius sp.	2.2	16.8	14.7
	Cinygmula sp.	20.7	2.0	0.33
III	*B. bicaudatus*	9.0	0.17	-
	Peltoperla sp.	4.3	13.2	2.3
	Heterlimnius sp.	1.0	6.2	4.8
DITCH CREEK				
	Cinygmula sp.	3.3	6.7	0.67
II	*B. bicaudatus*	4.0	3.0	0.17
	Peltoperla sp.	4.3	36.5	6.3
	Heterlimnius sp.	1.7	13.2	9.8
	Cinygmula sp.	1.7	2.0	0.17
III	*B. bicaudatus*	0.5	0.17	-
	Peltoperla sp.	0.5	38.0	2.8
	Heterlimnius sp.	-	8.0	12.0
EGGERS CREEK				
	Cinygmula sp.	1.0	2.2	2.5
II	*B. bicaudatus*	0.83	0.17	-
	Peltoperla sp.	10.0	31.0	23.8
	Heterlimnius sp.	7.5	17.3	26.2
	Cinyymula sp.	1.7	1.8	1.5
III	*B. bicaudatus*	3.7	-	0.33
	Peltoperla sp.	4.0	2.8	1.7
	Heterlimnius sp.	0.83	8.0	20.3

Table 19. Organic sample analysis showing the number of species, total insect density, midge density, species diversity and evenness for samples taken on Control, Ditch and Eggers Creeks in July and August 1975. *Midges not included.

			Total Number of Species			
		Species*	Number/m^2	Midges/m^2	Diversity*	Evenness*
July						
Control	I	19	2357	646	2.70	0.65
	II	14	1206	334	2.49	0.73
Eggers	I	13	2185	1808	2.60	0.75
	II	8	1442	1281	1.85	0.83
August						
Control	I	11	689	484	2.37	0.79
	II	10	420	269	2.01	0.79
Ditch	I	12	527	22	2.02	0.65
	II	15	1259	269	2.25	0.61
Eggers	I	9	1378	947	1.60	0.62
	II	12	743	237	2.13	0.68

was relatively low, the densities were surprisingly high during July, ranging from 1,206 to 2,357 insects/^{2}m. Densities in August were appreciably lower with the lowest densities occurring in Control Creek. A large proportion of the total density of insects recovered from these samples was represented by midges of the family Chironomidae. Diversity values were relatively low ranging from 1.60 to 2.70 during the July and August samples.

Insect Drift Across Sediment Debris Dams

Insect drift is one of the dynamic means by which insects colonize downstream areas. Insect drift taken above, at and below the sediment debris dams on Control and Eggers Creeks are shown in Apendix B-F. Drift was taken at four time periods encompassing both dark and light conditions and reflected a diel behavorial pattern. Large nighttime drift occurred on Eggers Creek except during July, 1975. Drift was much greater at the above and below dam sites than at the dam outflow. Insects were recorded in drift nets at the dam outflow, however, densities were low. Large drift densities were noted below the debris dam on Control Creek in August 1975, however, low drift densities were recorded above the dam. The largest number of drifting insects passing over the dam outflow occurred at 7:00 a.m. in August, 1975 at Control Creek. Eggers Creek drift during July 1975 is an anomaly in that peak drift occurred at 1:00 p.m. when 582 insects were taken in the drift below the dam. By contrast, drift above the debris dam had a prominant nighttime peak with drift density far exceeding other time periods. Because of the unusual pattern of drift below the dam on Eggers Creek, a similar test was conducted August 3, 1976 for validation purposes. Insect drift above the dam reflected a nighttime peak with lowest drift at 1:00 p.m. Drift at the

dam outflow was very low and represented by 13 insects during a one-hour sampling period. Drift below the dam was peculiar in that the highest drift occurred in the morning at 7:00 a.m. and represented nearly twice as many insects as during the previous night sampling period of 12:00 a.m.

For the purpose of contributing greater resolution to the different kinds of insects in drift, Appendices G-K reflect the ordinal composition of insects for Ephemeroptera, Plecoptera, Trichoptera, Diptera and Coleoptera for three sites on Control and Eggers Creeks. Insects in the order Ephemeroptera and Diptera represent the principal drift components. It is significant to note that while drift densities at the dam outflow were low, most of the principal orders of insects represented in the more typical riffle habitats were recorded there also.

DISCUSSION

Sedimentation and Flow

Control, Eggers and Ditch Creeks manifest unique features regarding sediment yield, discharge and surface sediment composition. These physical factors inherent to the stream itself plus exogenous factors of the watersheds tend to influence the insect distribution and abundance, both on a micro and macroenvironmental basis. Prior to this study, no logging had taken place in the Silver Creek watersheds, therefore, the physical manifestations of the drainages were essentially pristine, with the exception of Ditch Creek, which contains a low standard road. Ditch Creek is by far the most unstable drainage of the three streams by virtue of the large sediments generated in this drainage; the long-term average indicates that Ditch Creek produces nearly twice as much sediment as Eggers Creek, and four times as much sediment as Control Creek. Because Control Creek is nearly twice as large as Ditch Creek in area, the percentage sediment yield/mi^2 is much greater in Ditch Creek.

During 1975 and 1976, the period to which this report addresses, considerable variation in sediment yield was noted among the three drainages based upon the long-term average (personal communication and supplementary data, Megahan). Control Creek supplanted Ditch Creek as the second largest sediment producer. Total volume of sediment generated in Control Creek during June 1975, was nearly comparable with that of Ditch Creek. During 1976, year, however, sediment yield in Ditch Creek increased by 22 percent, while in Control and Ditch Creeks decreased appreciably. These anomalies between years are to a large degree due to the inherent abilities of these drainages to differentially store sediments and discharge them during the spring flood event.

Ditch Creek has the largest number of obstruction per unit length of channel, and highest sediment storage capability. The sediments stored are largely sands which have a potentially diminishing effect upon insect diversity and abundance. After each spring flood event, the stream is "recharged" leaving it in a dynamic stable state, subject, however, to catastrophic summer and fall thunderstorms causing degradation, aggregation and relocation of sediments.

A 20 percent decrease in the number of retention structures in Ditch Creek during the years of 1973 and 1974 suggest potentially large between-year differences in sediment storage. Reduction in the number of obstructions were noted to some degree in Control and Eggers Creeks, but to a lesser degree.

Many factors are responsible for the kind and frequency of obstructions and their stability within stream channels. First, the amount and kind of debris, within, spanning or adjacent to the channels is a major factor. The physical nature of the channel itself with respect to bedrock, boulders and cobbles tends to provide a basis for further accumulation of organic debris. The gradient of the channels and the magnitude of hydrological events are perhaps two of the principal factors contributing to large between-year differences in numbers and kinds of obstructions. Higher gradient streams would potentially generate greater energies resulting in displacment, undercutting or various shifting of obstructions. The severity of hydrological events, such as midsummer thunderstorms, also influences the stability of the obstructions. For purposes of contrast, Eggers Creek has the greatest channel gradient (22 percent grade), while Ditch Creek has the least (15.2 percent).

When reviewing the hydrographs for the three streams, it is noted that there have been departures in the time of peak flows. Peak flows

generally occur in April or May. Because of the inherent variability in peak flows between years, the associated insect communities have developed an inherent resilience to accommodate these changes, thus not jeopardizing the life cycles. Extreme departures from the norm could be potentially destructive to some species by differentially affecting sensitive life stages such as eggs or early instar larvae.

An interesting feature about the Silver Creek watersheds is that the largest annual sediment yield does not necessarily occur during a year that has a high runoff. During years of extremely low flow and nominal peak discharge the streams have an inherent capacity to store sediments. During the ensuing spring runoff large amounts of sediments are displaced as reflected by water years 1973-74 and 1974-75. In Ditch Creek, and to a lesser degree in Control Creek, a much greater volume of sediment was released in 1974 than 1975 in spite of a relatively high spring discharge in 1975.

Surface roughness and permeability of the streambed undoubtedly play an important role in sediment storage. Intensive study sites below the debris dams during 1975 were annually subjected to large sediment releases from the debris dams. All the sediments accumulated in the dams during the course of a year were released over a few hours. Our analysis of the surface sediment condition prior to (May) and after sediment releases (June) indicated that the percentage of surface sands increased in the sites below the dams at each of the three creeks (Tables 8-10). Increase in surface sands was greatest in Ditch Creek and least in Control Creek in 1976. It is interesting to note, however, that surface sediment at the site below the dam on Control Creek prior to sediment release, contained a much higher percentage of sands than did its counterpart station on Ditch Creek. Changes in the surface sediment composition below sediment dams occur largely

as a result of two conditions: 1) the existing sediments (at least some of them) are partially displaced, thus accommodating incoming sediments from the sediment dam, or 2) incoming sediments largely pass over the existing streambed and out of the reach.

Five to six channel profiles across each of the study sites below the debris dam, indicated considerable channel stability prior to and after spring sediment release during 1976. Control Creek essentially reflected no change between these two time periods; Ditch Creek, the most unstable of the three drainages studied, had a 2 percent average degradation, while Eggers Creek had a 1.4 percent aggregation of sediments. It is my tentative interpretation that the sediments released from the debris dam are largely displaced over the surface of the existing streambed, rather than replacing existing sediments of pebble size or larger. Additional studies will hopefully contribute to greater resolution on this point. It should be pointed out, however, that surface displacement of sediments from the dam is contingent upon the stability of the existing retention structures inherent within the intensive study sites. It is acknowledged that displacement of retention devices having a vertical drop of one foot or more, would cause obvious scouring and displacement of sediments. An examination of surface maps of the intensive study sites reveals little evidence of position changes of the retention structures during the course of this study.

Insect-Substrate Relationships

Many aquatic insects, like most organisms, have affinities to specific habitats. First and second order streams of Control, Ditch and Eggers Creeks are obviously limited by discharge, i.e. they are small in size, and have a shallow water column. Current velocities may vary

considerably depending upon the gradient and surface roughness.

One of the biggest factors influencing distribution and abundance of insects in small streams is the nature of the substrate. The substrate in the Silver Creek watersheds may vary from large isolated boulders to almost uniform sand. Within a given watershed, the stream manifests a habitat mosaic of riffles and pools that provide a host of places where insects can reside. Some species may be restrictive in their habitat, living primarily in fine interstitial sands and gravel, others may prefer pebbles and cobbles where relatively high current velocities pass over the surface, others have affinities to organic debris accumulations. Within the insect community, however, a large majority of the species are found in not one, but several habitat types. Species differences between streams may be due to inimical features outside of the stream such as shading, riparian vegetation, deadfall, etc., rather than conditions within the stream itself.

Because logging activities are usually associated with sedimentation, the following discussion attempts to describe the insect communities associated with habitats largely demarcated by substrate characteristics within the streams prior to logging. I will discuss the insect communities in relation to substrate associations. Because organic accumulations in the form of semi-decomposed leaves, bark, twigs, branches and logs are separately discussed in this report, this discussion will center around the physical characteristics of the mineral substrate and the associated insect fauna.

<u>Cobble Habitats</u>. Cobble habitats are those having a preponderance of cobble-sized rocks ranging from 2.5 to 10 inches in diameter and are the most prevalent feature of the streambed. Sediments surrounding

cobbles are variable and sort out in relation to the energies surrounding the cobbles. While cobbles are not universally prevalent in the drainages studied, they are present to a modest degree. Habitats having a prevalence of cobbles associated with relatively course surrounding sediments promote the most diverse assemblage of insects in the streams. Mayflies, stoneflies and caddisflies are common. In the Silver Creek watersheds the mayfly _Cinygmula_ and _Baetis bicaudatus_ are two of the principal mayfly species. _Peltoperla_ and _Alloperla_ are the principal stoneflies. _Peltoperla_, because of its apparent affinity to semi-shaded, canopied streams and courser type sediments, will undoubtedly be an excellent indicator species for future evaluation of logging practices. The order Trichoptera contained the largest number of species in cobble habitats. The genera _Rhyacophila_ (a free-living caddisfly), _Micrasema_ and _Neothremma_ exhibited the largest densities within this order. The riffle beetle complex composed primarily by _Heterlimnius_ sp. is also prevalent, however, it extends its distributional range and abundance to all three habitat types discussed in this section. Dipterans, especially those other than chironomids, were poorly represented in cobble type habitats particularly when cobbles were in association with pebbles and pea gravel.

Pebble Habitat. Pebble habitats used in the context of this report are those having a preponderance of surface sediments ranging from 1/4 to 2.5 inches in diameter. This habitat type is the dominant type in the intensive study sites above debris dams. Like cobble habitats, pebble habitats have a large surface area on or around which insects can reside. Fewer species of mayflies and caddisflies were noted in this habitat when compared to cobble habitats. The mayfly _Cinygmula_ and _Baetis_ were

abundant and the caddisflies _Rhyacophila_ and _Neothremma_ were well represented. Fewer species of mayflies and caddisflies is not necessarily reflective of a poor habitat since many of the species found in the cobble habitats were very sparse and in some cases represented by a single specimen. The stonefly _Peltoperla_ was again the predominant member of this order and attained perhaps its greatest abundance in pebble habitats. The dipteran constituent of the insect community increased in both numbers of species and density when compared to the cobble habitats. The chironomid midges, unidentifiable for the most part to species, were largely responsible for increased densities. The riffle beetle _Heterlimnius_ is well represented in the pebble habitat and constitutes the bulk of the coleopterans.

Sand Habitats. Sands used in the context of this report include particle sizes ranging from less than 1 mm to 6.4 mm in size. The surface sediment classification used to describe substrate types has no provision for silts which are present to some degree in all streams. However, silts seldom represent a dominant condition in the Silver Creek watersheds and are not sufficiently abundant to exert a controlling influence over the microenvironment of insects. Therefore, discussion will center around grain sizes that are predominantly sand. Sands, while prevalent as a dominant surface condition in the Silver Creek watersheds, also occur within the interstices of courser particles of pebbles and cobbles, therefore, influence in a major way the microenvironment of larger substrate particle sizes. Sands reduce the permeability of the interstices, thus inhibit interstitial penetration into the deeper sediments by many of the stream insects.

Heavy concentrations of sands produce the most biologically impoverished conditions for aquatic insects. Stoneflies, mayflies and caddisflies prevalent in cobble and pebble habitats are most severely affected. These orders are represented by fewer species and extremely low densities. Two orders of aquatic insects, however, are well represented in this habitat type. Coleoptera, represented almost exclusively by _Heterlimnius_, was well represented, however, overall densities were considerably lower than in the pebble and cobble habitats. Dipteran diversity increased, i.e. more species were found than from the other habitat types; however, densities were not appreciably different from larger particle-sized substrates. Chironomid midges were the dominant dipterans, with the tipulids, _Hexatoma_ and _Dicranota_ secondarily important. Appreciable faunistic differences were noted between streams for this habitat type. Control Creek had the most diverse dipteran population, Ditch Creek the least.

The Impact of Sediment Releases from Debris Dams on Downstream Insect Communities

A point of considerable interest to forest resource managers is the extent to which large sediment releases have upon the insect community and the recoverability of that community after the impact has subsided. Sediment releases from sediment dams constructed to monitor sediment recruitment, permitted such an analysis. During 1976 new intensive study sites were established 40-80 m below the debris dams. The numbers of the species present in the intensive study sites at Control and Eggers Creeks, prior to and after sediment releases, were essentially the same. However, a noticeable increase from 7-22 species was noted in Ditch Creek. The latter is an unexpected and unexplainable

phenomenon at this point in time. The numbers of species remaining after a perturbation is only one measure of biological resilience. Density, in many respects, is a more meaningful measure. Average densities at Control and Ditch Creek sites below the sediment dams decreased approximately 20 percent after sediment release (Table 14). By means of comparison, the respective sites above the debris dams increased in density by more than 100 percent. The anomalous increase in average density of insects in Ditch Creek (from $45\text{-}247/m^2$) is again a surprising and unexplainable phenomenon. The corresponding site above the debris dam on Ditch Creek also increased in density between the two sampling dates but at a much lower level.

While I cannot emphatically state that sediment releases have or do not have an impact on the insect community below the debris dams, it is apparent that if existing populations were not able to endure the abrasion and scour of sediments, colonization from upstream areas was relatively rapid and of sufficient magnitude to largely replace the community that existed prior to sediment release.

Two of the remarkable features about streams suffering impaction of sediments and potential destruction to life within the system, is the ability of streams to remove the sediment burden given average or above average flood events and the ability of insects to recolonize locally impacted areas. Quick benthic insect recoverability is contingent upon the presence of thriving populations either above and/or below an impact area so that recolonization can occur by drift, upstream migration within the water column or aerial migration. Streams having heavy sediment impaction over major reaches would be expected to have a much slower recovery--perhaps requiring several years.

Role of Organic Loading on Benthic Insects

The amount and type of organic material in stream channels is one of the fundamentally important ecological conditions relating to stream habitat quality. First and second order streams in the Silver Creek drainage, like most streams in the Idaho batholith, are heterotrophic, i.e. the principal energy source has its origin from other than the stream itself. In other words, photosynthesis is not an active process in streams having dense tree canopies.

The number of species found in the organic debris community were much fewer than in habitats having mineral substrate. Chironomid dipterans were the most abundant insects, followed by mayflies and stoneflies. The mayflies *Ameletus cooki* and *A. similor* were the principal mayflies during mid-summer. In August, however, *Ephemerella tibialis* became the dominant form. The stoneflies *Alloperla* sp. and *Paraperla* sp. were the dominant stoneflies. It is significant to note that the stonefly *Peltoperla* was not common in the organic debris accumulations while very common in mineral substrates. Because of the specific habitat requirements of this species, this stonefly will undoubtedly be an excellent indicator of habitat changes regarding organic accumulations resulting from logging. Caddisflies, which are often abundant and important processors of organic debris, were relatively sparse in the watersheds investigated. Many play an active role in the decomposition of organics and are instrumental in hastening the conversion of organics to mineral substance. The genera *Lepidostoma* and *Dicosmoecus* were the principal caddisflies recovered in organics. It is probable that their numbers will increase as the canopies above the streams open and organic material increase in the channels.

I wish to qualify the importance of organic debris in streams with regard to its beneficial and detrimental features. Organics in the form of tree trunks, stems and branches, may form obstructions resulting in vertical drops and miniature impoundments. These materials are relatively slow to decompose and may cause side effects such as shading that could preclude rapid processing and decomposition by microbes and the associated insect fauna. Particulate organic matter in the form of semi-decomposed leaves, needles and bark, however, provide considerable surface area which microbial organisms and insects can process, thus releasing energy bound within the molecules of this material. This processing leads to increased transfer of energy into higher trophic levels rather than being displaced in its semi-decomposed state to a lower reach of the river or out of the system altogether.

The present condition of surface and interstitial organics in the experimental watersheds is natural and cannot be construed as detrimental to the productivity and diversity of the biotic community. If large organic accumulations should occur as a result of logging practices, a reassessment of the type and amount of organics could conceivably result in a negative appraisal of this material.

It should be pointed out in the context of species diversity and species richness, that, while the numbers of species associated with this habitat type were relatively few, the density in many cases was equivalent to or greater than densities from mineral substrates. The reason for the high density was largely the result of the preponderance of chironomid midges.

Role of Natural and Man-Made Debris Dams Upon Distribution and Ecology of Stream Insects

The role of natural and man-made blockages or debris dams in first and second order streams is a point of considerable interest when managing these streams. The principal focus of this study was on man-made debris dams which have a 1.0 to 1.5 m vertical face and an upstream pool approximately 12 m long. The pool behind the dam is essentially lentic in that little or no current is detectable because of the low discharge generated from the streams during most months of the year. Sampling was not done directly in the pool because of interference and disturbance of the sediments which were being monitored by the Forest Service. Therefore, benthic insect sampling was done above, below and at the outflow of the dam.

From insect drift studies conducted at these locations, it is apparent that the debris dams represent formidable, ecological blockages in the downstream drift of insects. They did not form an absolute blockage in that key lotic species moved across the dams and were collected at the outflows; the numbers were not sufficient to indicate successful transmission across the dams for the majority of individuals, however.

The number of drifting insects was usually greatest during the 11:00 to midnight sample period both above and below the dam (Appendix B-K). Drift at the dam outflow was very low with no apparent consistent peak. Dominant drift species above and below the dam were the mayfly, Baetis bicaudatus, the stoneflies, Alloperla and Peltoperla, the caddisflies, Lepidostoma and Rhyacophila, and the riffle beetle, Heterlimnius corpulentus. Midge larvae, unidentifiable to species, were the most abundant dipterans in drift. The appearance of the caddisflies, Lepidostoma and Rhyacophila and the beetle Heterlimnius in drift samples

at the dam outflow can in part be explained by their observed presence in the pool above the dam feeding or otherwise residing upon rubble on the bottom of the pond and dam face. Their presence in the drift could be accidental rather than active displacement. It is unlikely that many insects pass across the pool on or near the surface of the water. Transmission across this area is likely along the bottom and up the vertical face of the wooden dam.

The peculiar drift pattern noted in Eggers Creek in July warrants special discussion and speculation. Because of the anomalous drift pattern shown there in 1975, a similar study was conducted in 1976. Insect drift during July below the dam was unpredictable both years. Midnight drift was not the peak drift as reflected in Control Creek. The mayfly, Baetis bicaudatus, was the principal drift insect below the dam. An age class examination of this species indicated it was an early instar and possibly in a state of hatching at the time drift was taken. Because a similar drift pattern was not noted for the site above the dam and because a mechanical disturbance to the stream would have been noted, I interpret the drift response to be a local condition possibly induced by hatching.

A significant point of these drift studies is that drift was actively taking place both above and below the debris dams but was minimal at the dam outflow. Correlating insect drift with bottom samples taken from the intensive study sites above and below the dam contribute further resolution to the role of sediment debris dams on the colonization cycle of insects. It was concluded earlier that drift was not an active mechanism of displacement across the pools; colonization immediately below the dam was nevertheless obvious because of the large numbers of insects recorded in drift from these areas. While the intensive

study sites for the experimental watersheds were located below the point where insect drift was taken, these sites generally showed a lower standing crop than similar sites located above the sediment dams.

It is significant to point out that drift is not the only means of colonizing stream habitats, in that most of the insects that live in the water as immatures, emerge from the water as adults and fly to new locations to oviposit and start the life processes over again. Because of the relatively large numbers of drifting insects immediately below the sediment dams and low transmittal of insects across dam pools, I conclude that colonization results largely from adult migration and oviposition in areas immediately below the dam face plus possible upstream movements within the stream itself. While the latter condition has been propounded as a means of colonization, (Ball et al., 1963; Bishop and Bishop, 1968), Brusven (1970) reported minimal upstream migration by selectively tagged insects in northern Idaho. Adult migration is likely the principal means of colonizing areas suffering ecological blockage to downstream drift.

Translating the findings of drift and colonization at the debris dam sites to the much smaller, natural occurring debris obstructions, such as logs, twigs and stems, I conclude that potential blockages of these types, under existing conditions, have a minimum effect on the colonization cycle of insects. Since natural stream obstructions in the investigated creeks have vertical drops usually of 1 ft or less, I contend they have a minor effect on insect colonization at the present time.

Logging Impact on Stream Insects--A Philosophical Analysis

Because logging did not occur in Control Creek as originally planned

during the time of this study, we cannot make definitive conclusions relative to the impact of logging on the insect community. We can, however, on the basis of the findings of this study and the earlier study of 1973-1974, make inferences to possible impacts from logging on benthic insects. Brown and Krygier (1970), Rothacher (1971), and Ponce (1974), point out obvious changes in stream environments resulting from timber harvest practices and road construction. They reported increased insulation, flow, organic loading, erosion and water temperature.

Timber harvest methodology in central Idaho may take several forms depending upon the sensitivity of the environment to logging. For example, clearcutting may be used where the topography and economics warrant it. Clearcutting may be done in several ways, e.g. conventional skidding and roads, balloon logging, or with a helicopter (helicopter logging is proposed for Control Creek experimental watershed). Because roads represent the biggest single source of sediments (Megahan, personal communication), elimination of roads by using alternate timber harvest methods, would reduce the potential of heavy sedimentation resulting from slumps, massive erosion, and bank failures. Selective cutting tends to leave a reasonable amount of cover, both trees and the lower understory, to buffer massive soil failure. The retaining of strip buffers adjacent to streams and unstable areas tends to further reduce the impact of sediments and debris on streams.

Removal of plant cover from a watershed can have obvious profound and subtle affects. Plant cover removal can result in increased water temperatures, particularly during the summer months. From a biological point of view, this could be disruptive to the life cycles of benthic invertebrates living in those streams, since it may hasten the rate of

development to a point where emergence may occur at a time which would be disadvantageous to the species. For example, eggs may hatch prematurely resulting in the initiation of a generation prior to the onset of winter, thus causing their demise. Side effects from increased temperatures could also result in reduction in dissolved oxygen, increased algal growth and microbial activity. The latter may not necessarily be undisirable.

Increased instantaneous flow is a probable result of logging and potentially increases erosion, especially during spring runoff. This could have a catastrophic effect upon the insect community by displacing large numbers of insects via drift and changing the habitat conditions to a form that would be untenable to many species, thus setting into motion major community shifts within the stream. We have noted from studies in the experimental watersheds already, that the high spring discharges in 1974 apparently were directly or indirectly responsible for the shifting of the community from a mayfly to a stonefly community in 1963 and 1974. The caddisflies and dipterans were largely unaffected.

Timber removal adjacent to streams potentially results in debris accumulations. Large amounts of debris tend to clog the stream in the form of miniature debris dams. These retention structures impede the flow, thus reduce the sediment transport capability of the stream. Sands and small particulate organics are most actively displaced during periods of high flow or summer rainstorms. They tend to settle out in reaches having low velocities and assume a rather permanent position until the onset of spring runoff or during a storm event. Impaction of the streambed with fine sediments, changes the habitat characteristics in a way that could result in profound changes in the insect community and total secondary production.

From a contrasting viewpoint, it is conceivable that large-scale debris cleaning operations in streams could be as detrimental as allowing excessive debris to accumulate. Massive debris removal would likely result in biologically impoverished conditions. The organic processing properties of the stream would be disrupted, permitting rapid transport of energy-bound materials out of the stream, resulting in a relatively sterile environment in which few insects, other invertebrates and fish could live in spite of favorable stream bottom conditions.

SUMMARY

Control, Ditch and Eggers Creeks were studied for the purposes of providing continuity with an earlier study to determine between-site, between-year and between-stream variations in insect-substrate relationships. Specifically, the study concerned itself with: 1) determining the impact of sediment dams and natural debris blockages on the colonization cycle of insects, 2) determining the effects of sediment removal from debris dams on downstream insect communities, and 3) evaluating the effect of organic loading on insect communities.

Surface sediment analysis of intensive study sites indicated that the predominant surface sediments were pebble and that the preponderance of fine sediments increased from early summer to fall. Ditch Creek has the highest sediment yield of the three streams studied and the largest frequency of channel obstructions. Between-year and between-stream differences in sediment yield are large and presumably the result of differences in watershed stability-sediment yielding properties associated with specific storm events.

Sediment released from debris dams resulted in increased surface sands below the intensive study sites.

Sediment dams occurring in the lower reaches of the experimental watersheds serve as formidable blockages to the normal downstream insect drift. Highest drift densities occurred typically during the night hours, lowest during the daylight hours. While debris dams inhibit normal downstream displacement of insects, these dams apparently do not result in unpopulated areas immediately below the outflow; large numbers of insects drifted from the reach immediately below the debris dams.

Cobble and pebble type substrates support the greatest diversity

and in most cases, density of insects in the experimental watersheds. Sand-laden substrates support a higher preponderance of dipterans, especially midges which live on or within the interstices of the sand. The elmid beetle, Heterlimnius, was prevalent in all three habitats of sand, cobbles and pebbles.

Organic debris accumulations promotes an insect community far different from that found on mineral substrates. The number of species is appreciably less than on pebble and cobble habitats, however, the densities are often comparable by virtue of the large numbers of chironomid dipterans. Caddisflies were not prevalent from the organic accumulations but potentially play an important role in the processing of stream organics.

Low profile obstructions in the form of rocks, logs, twigs and limbs, increase retention of organics and sediments. Processing of retained organics permits release of energy rather than massive displacement of unprocessed organics from the system.

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Appendix A. Checklist of insect species found in the Silver Creek experimental watershed. *=new species added to list since 1975 report, Brusven and Hart.

EPHEMEROPTERA

Ameletus cooki McDunnough
Ameletus similor McDunnough
Baetis bicaudatus Dodds
Baetis tricaudatus Dodds
Cinygma sp.
Cinygmula sp.
Epeorus albertae (McDunnough)
Epeorus longimanus (Eaton)
Ephemerella doddsi Needham
Ephemerella flavilinea McDunnough
Ephemerella hecuba (Eaton)
Ephemerella hystrix Traver
Ephemerella infrequens McDunnough
Ephemerella margarita Needham
Ephemerella spinifera Needham
Ephemerella tibialis McDunnough
Heptagenia criddlei McDunnough*
Paraleptophlebia bicornuta (McDunnough)*
Rithrogena hageni Eaton

PLECOPTERA

Acroneuria sp.
Alloperla sp.
Arcynopteryx sp.
Isogenus sp.
Isoperla sp.*
Leuctra sp.
Nemoura sp.
Paraperla sp.
Peltoperla sp.
Pteronarcys sp.

TRICHOPTERA

Arctopsyche grandis (Banks)
Chyranda centralis (Banks)*
Cryptochia sp.
Dicosmoecus sp.
Dolophilodes sp. (formerly *Sortosa*)
Glossosoma sp.
Hydroptila sp.
Lepidostoma sp.
Micrasema sp.
Neophylax sp.

TRICHOPTERA (con't.)

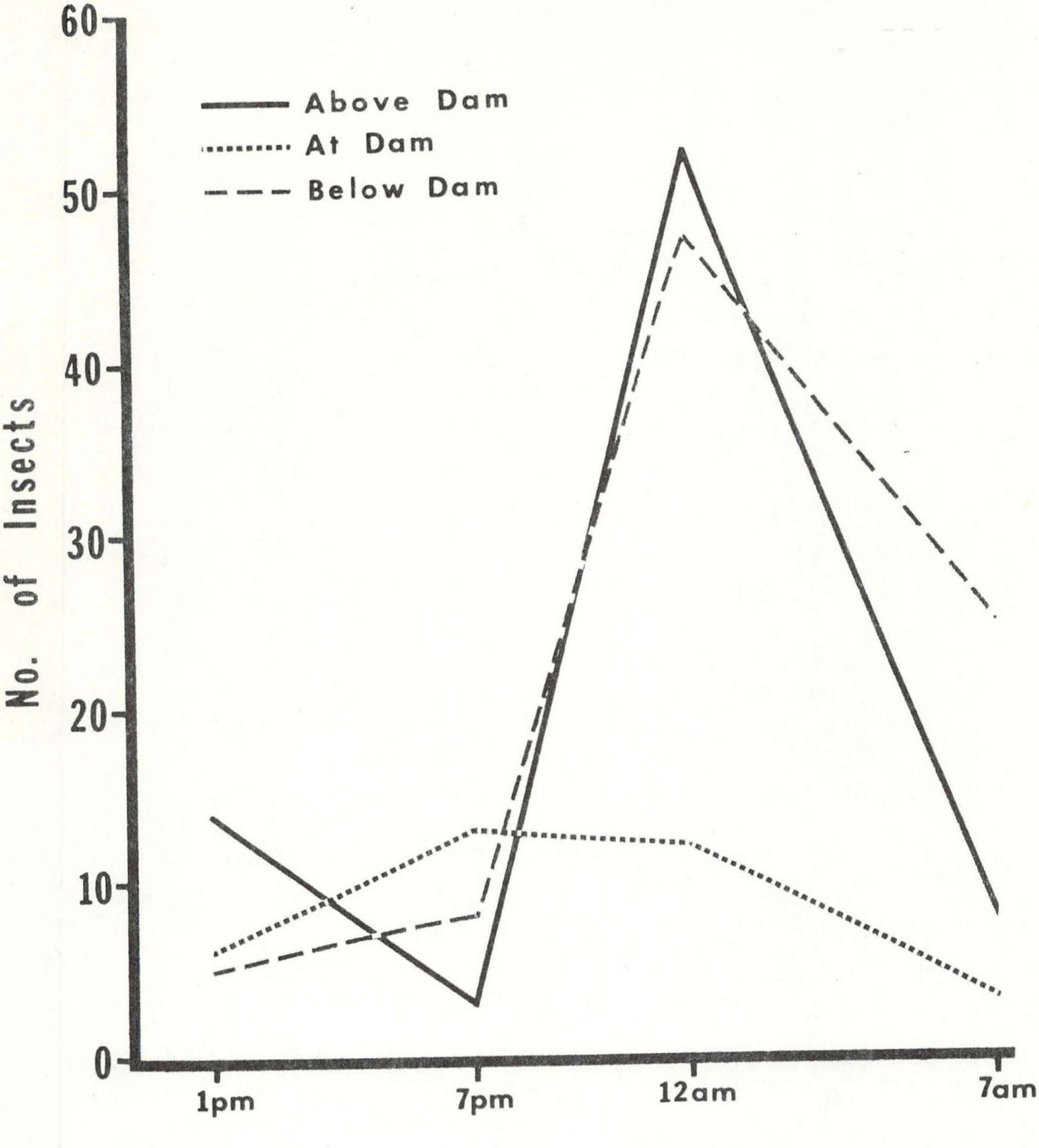
Neothremma sp.
Neotrichia sp.*
Parapsyche almota Ross*
Parapsyche elsis Milne
Psychloglypha sp.
Rhyacophila acropedes Banks
Rhyacophila angelita Banks
Rhyacophila hyalinata Banks
Rhyacophila vaccua Milne
Rhyacophila vagrita Milne
Rhyacophila vepulsa Milne
Rhyacophila verrula Milne

DIPTERA

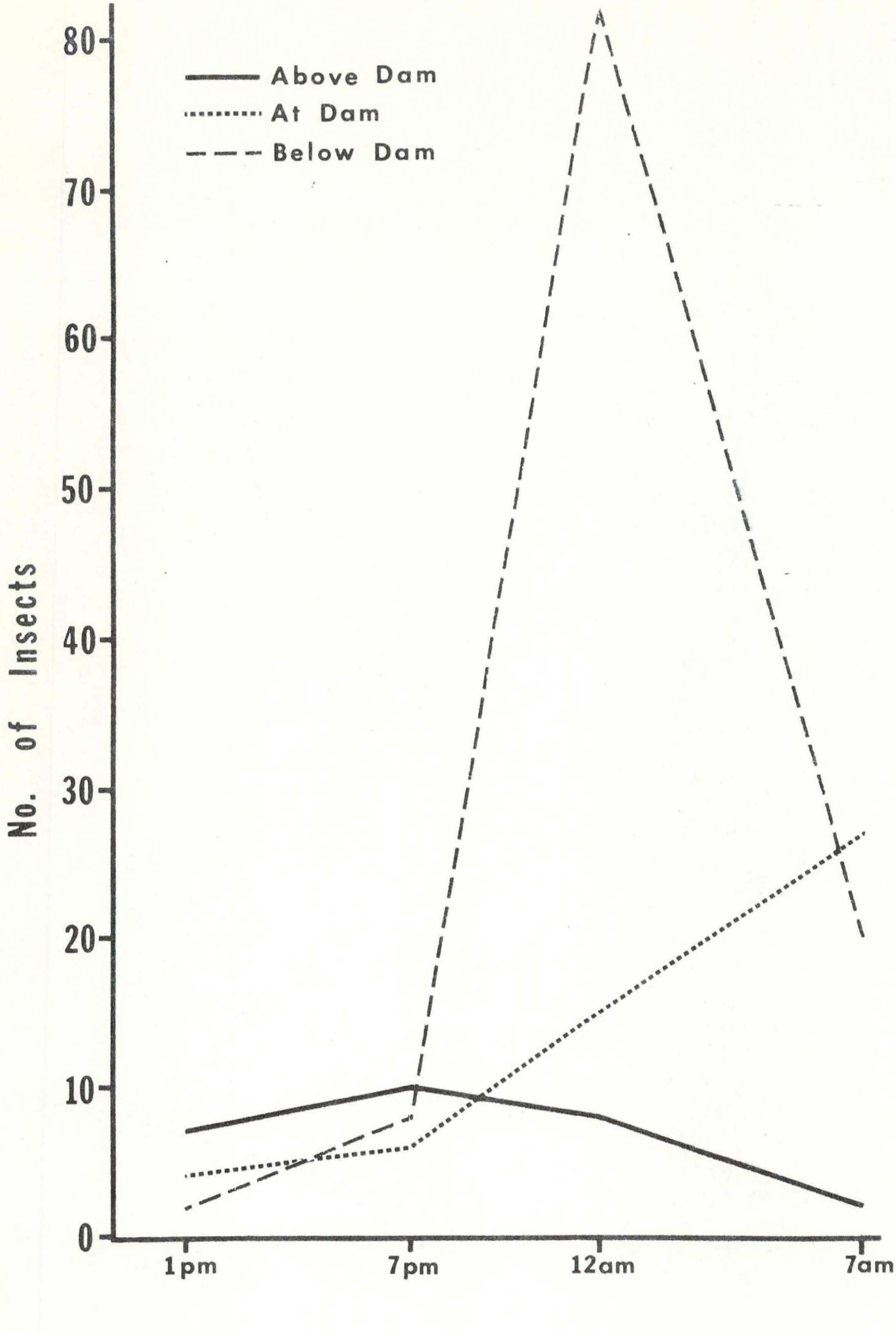
Antherix variegata Walker
Antocha sp.
Ceratopogonidae (sp.)
Chironomidae spp.
Dicranota sp.
Dixa sp.
Empididae sp. 1
sp. 2
Ephidridae (sp.)
Holorusia sp.*
Hexatoma sp.
Limnophila sp.
Limonia sp.*
Liriope sp.
Palpomyia sp.*
Pericoma sp.*
Polymeda sp.*
Prionocera sp.
Psychodidae sp. 1
sp. 2
sp. 3
Rhabdomastix sp.
Simulium sp.
Thaumalea sp.*
Tipulidae sp. 1
sp. 2
Tubifera sp.*
Wiedemannia sp.*

COLEOPTERA

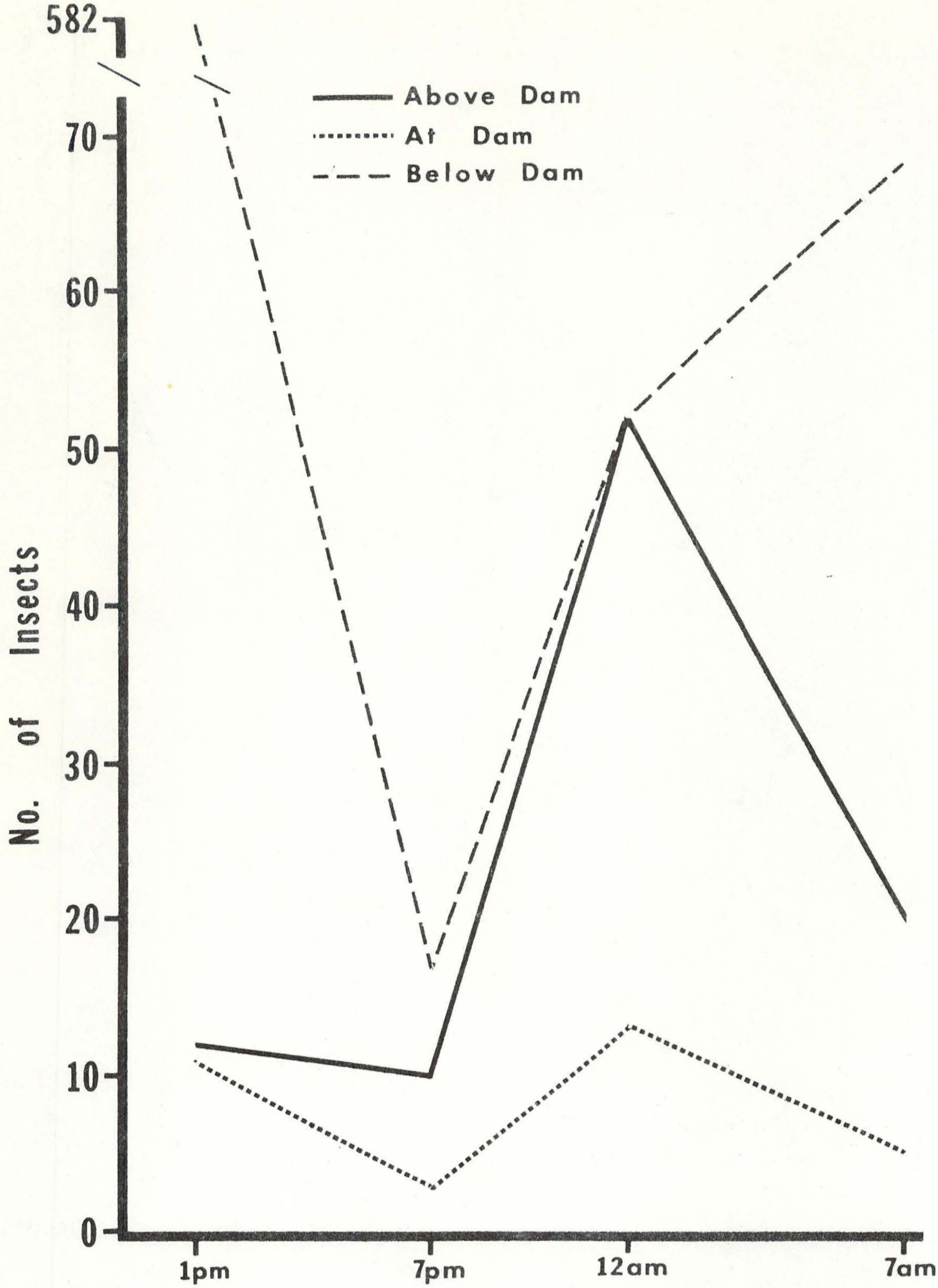
Amphizoa insolens LeConte
Helichus sp.
Heterlimnius corpulentus (LeConte)
Hydrobius sp.*
Hydrophilidae (sp.)
Hydroporus sp.
Lara sp.
Narpus sp.
Optioservus seriatus (LeConte)
Rhantus sp.*
Zaitzevia parvula Horn



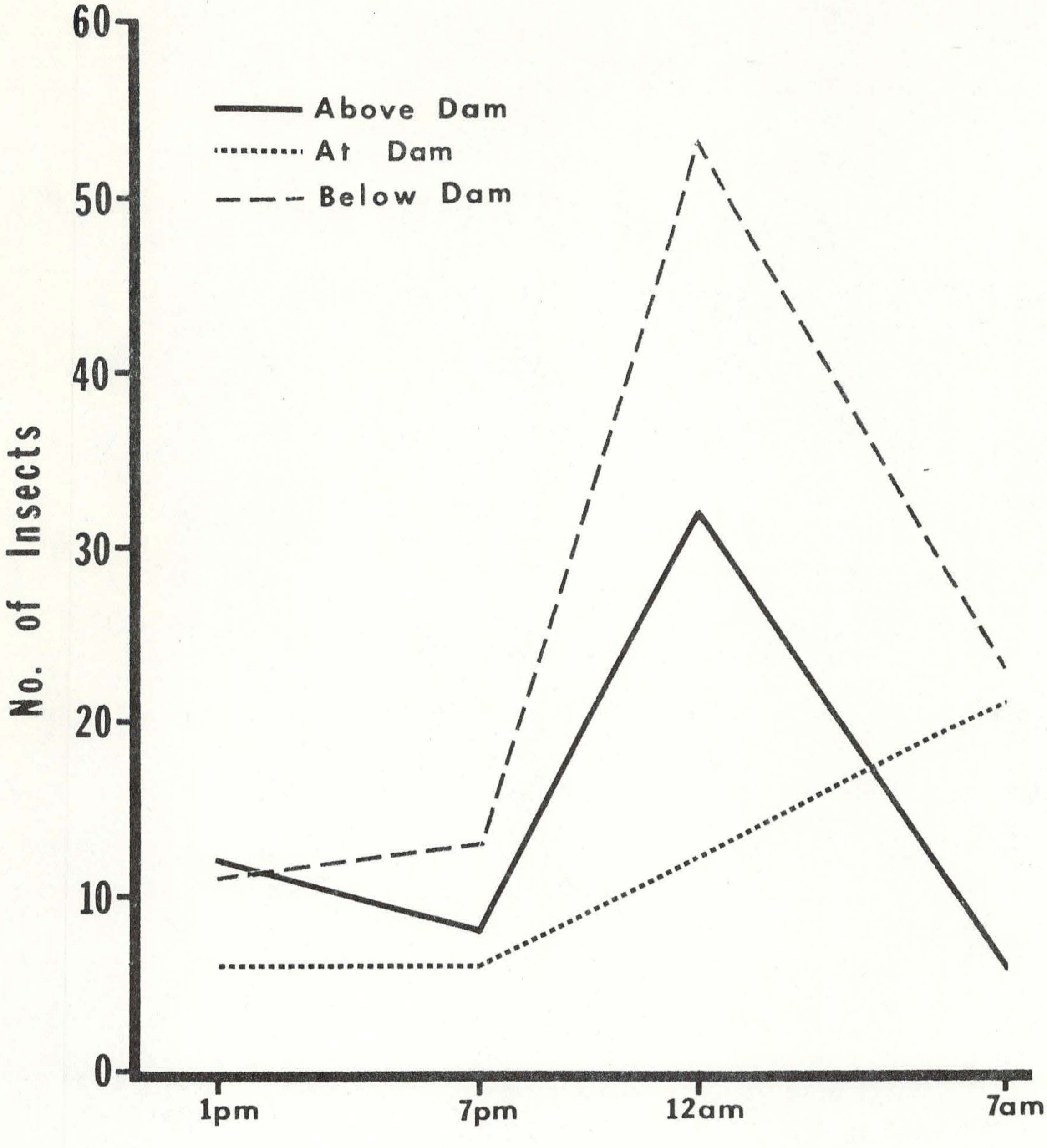
Appendix B. Total insect drift at Control Creek, July 21, 1975.



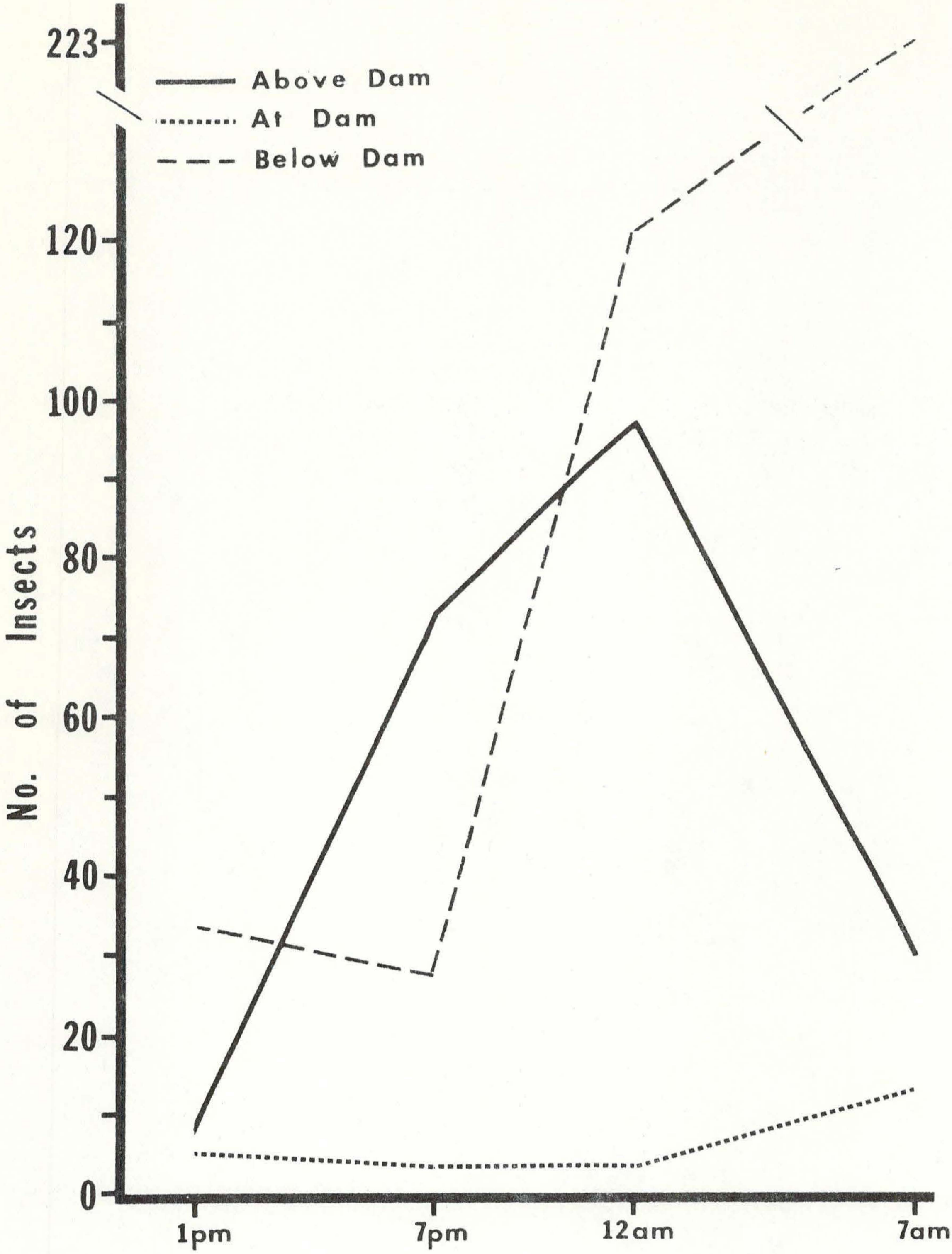
Appendix C. Total insect drift at Control Creek, August 16, 1975.



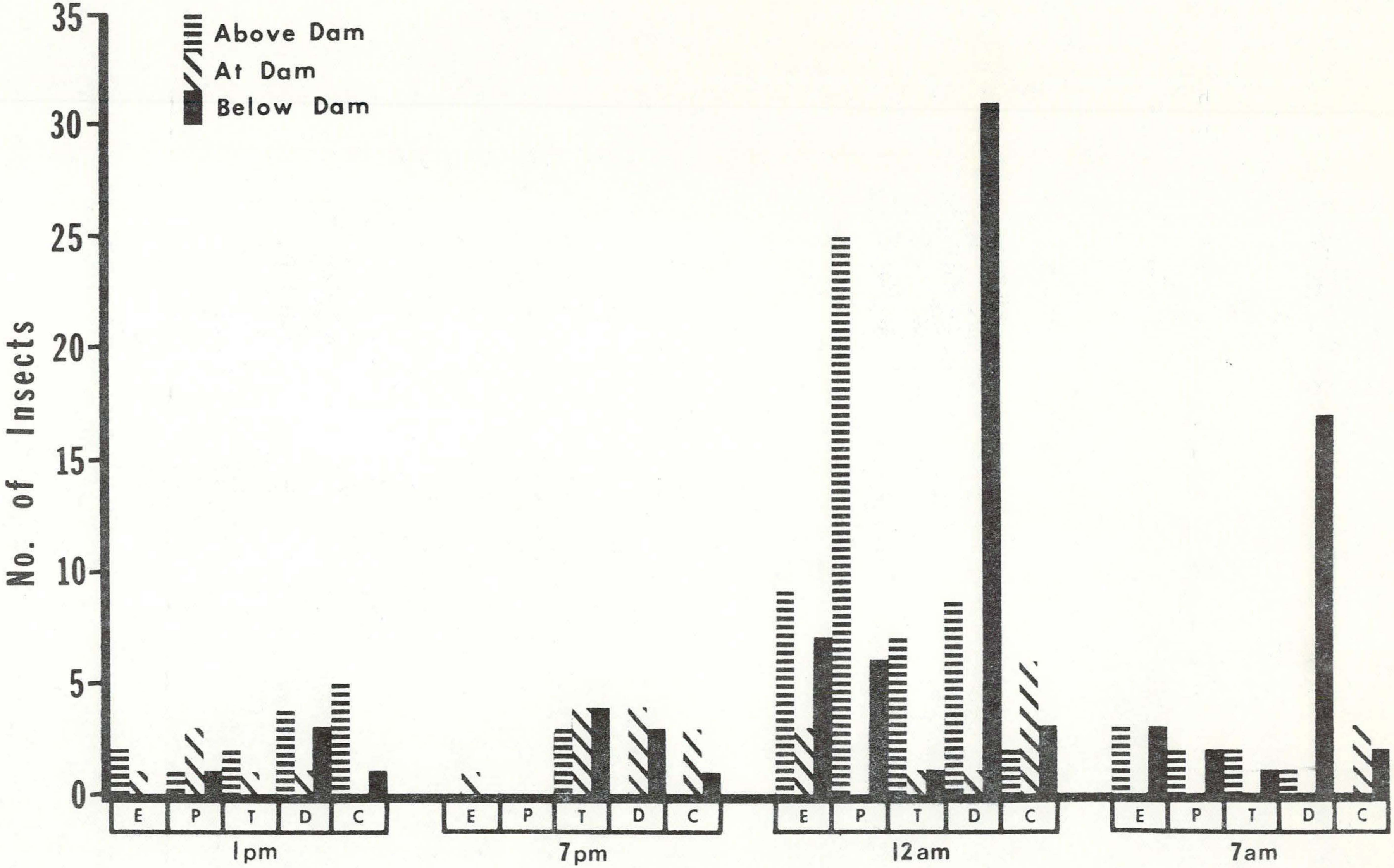
Appendix D. Total insect drift at Eggers Creek, July 22, 1975.



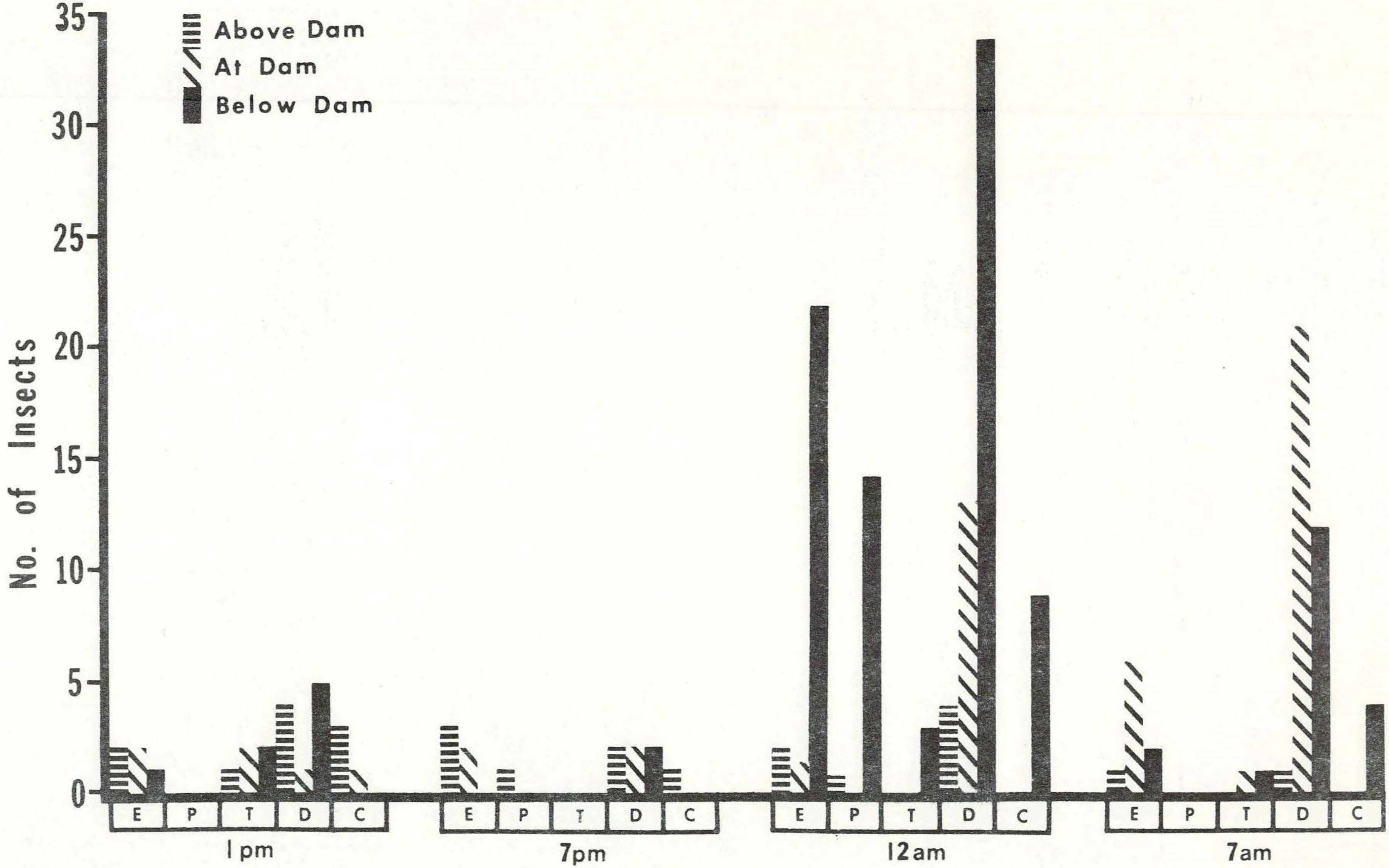
Appendix E. Total insect drift at Eggers Creek, August 13, 1975.



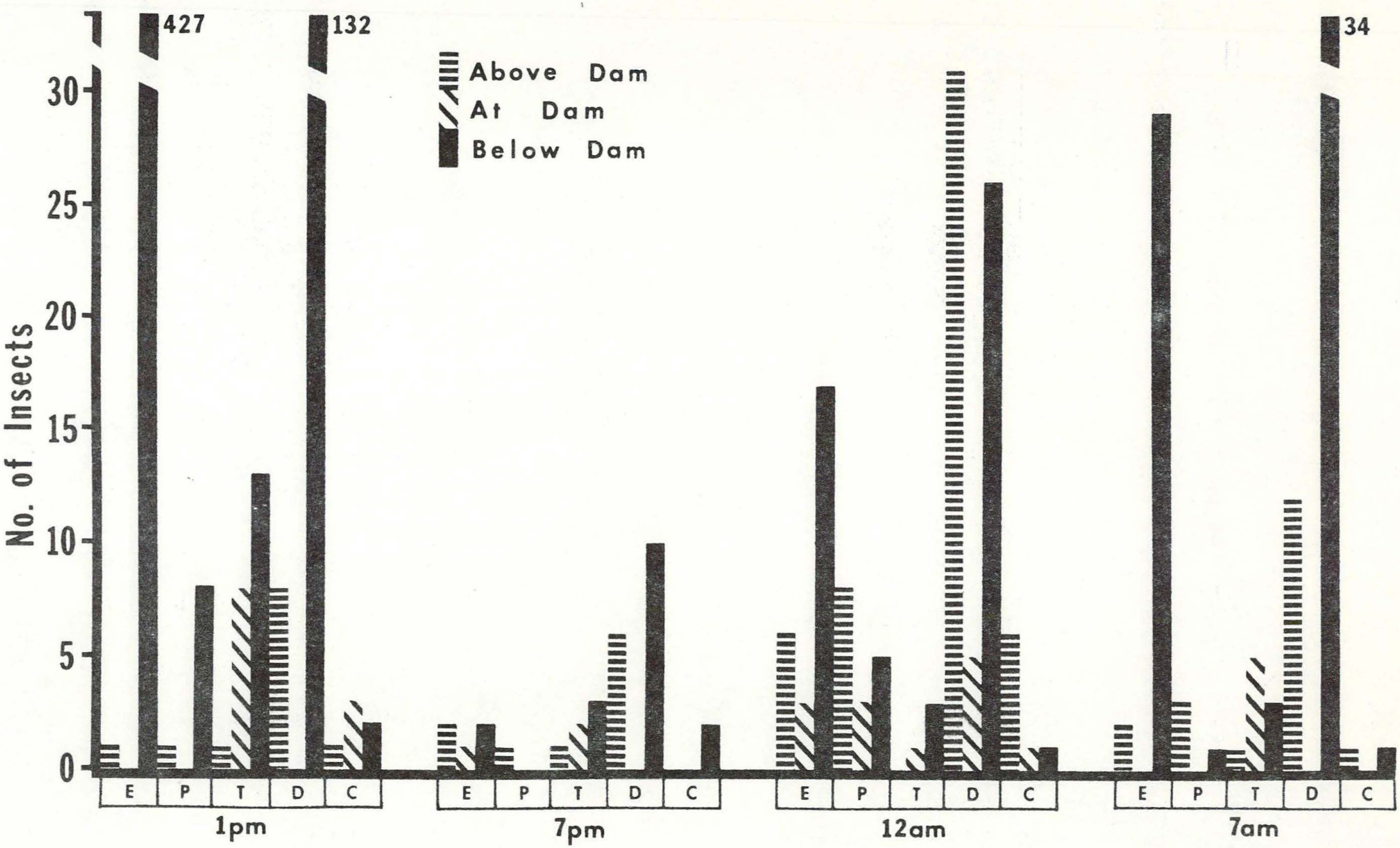
Appendix F. Total insect drift at Eggers Creek, August 3, 1976.



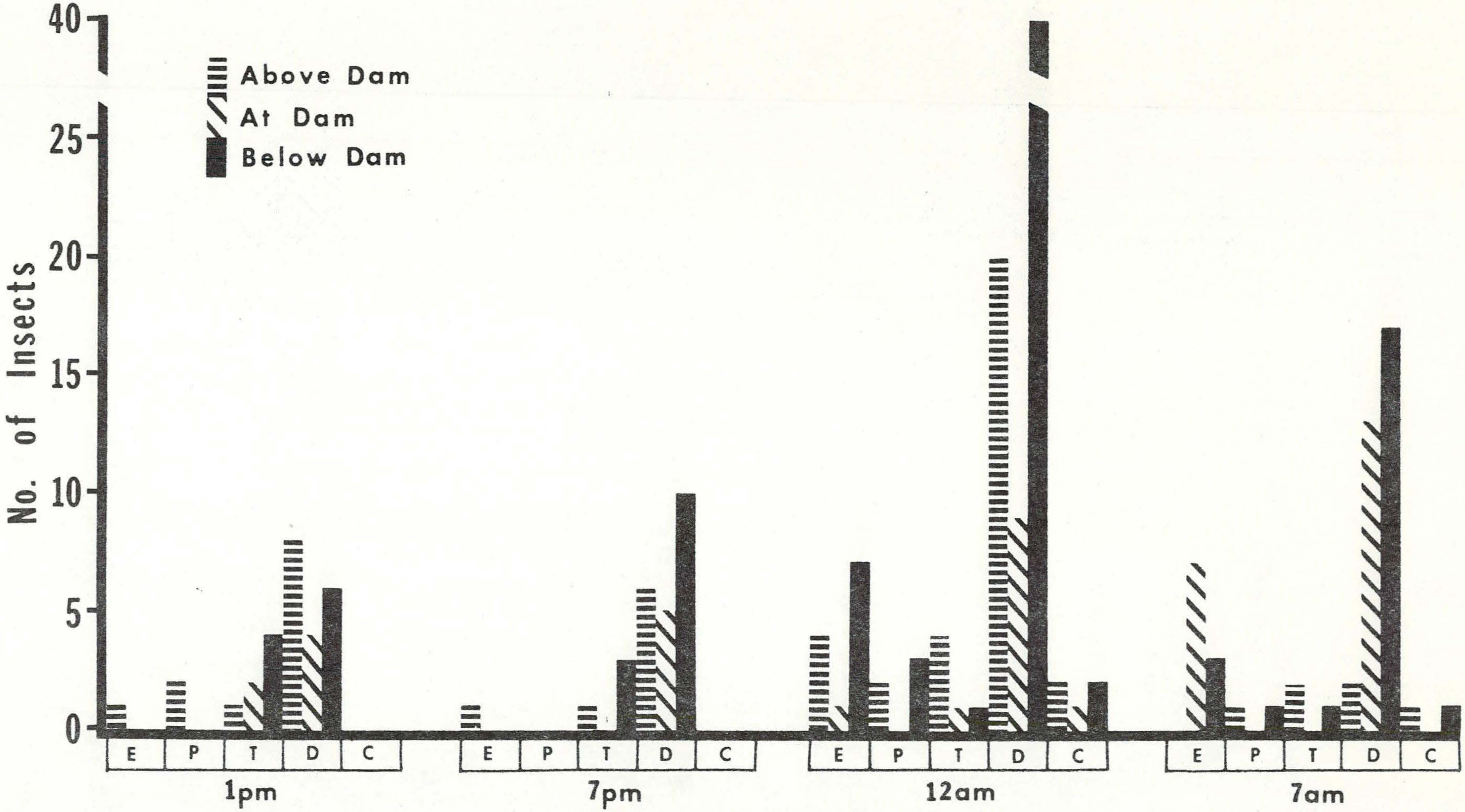
Appendix G. Ordinal insect drift for Control Creek, July 21, 1975.
E = Ephemeroptera, P = Plecoptera, T= Trichoptera, D = Diptera, and C = Coleoptera



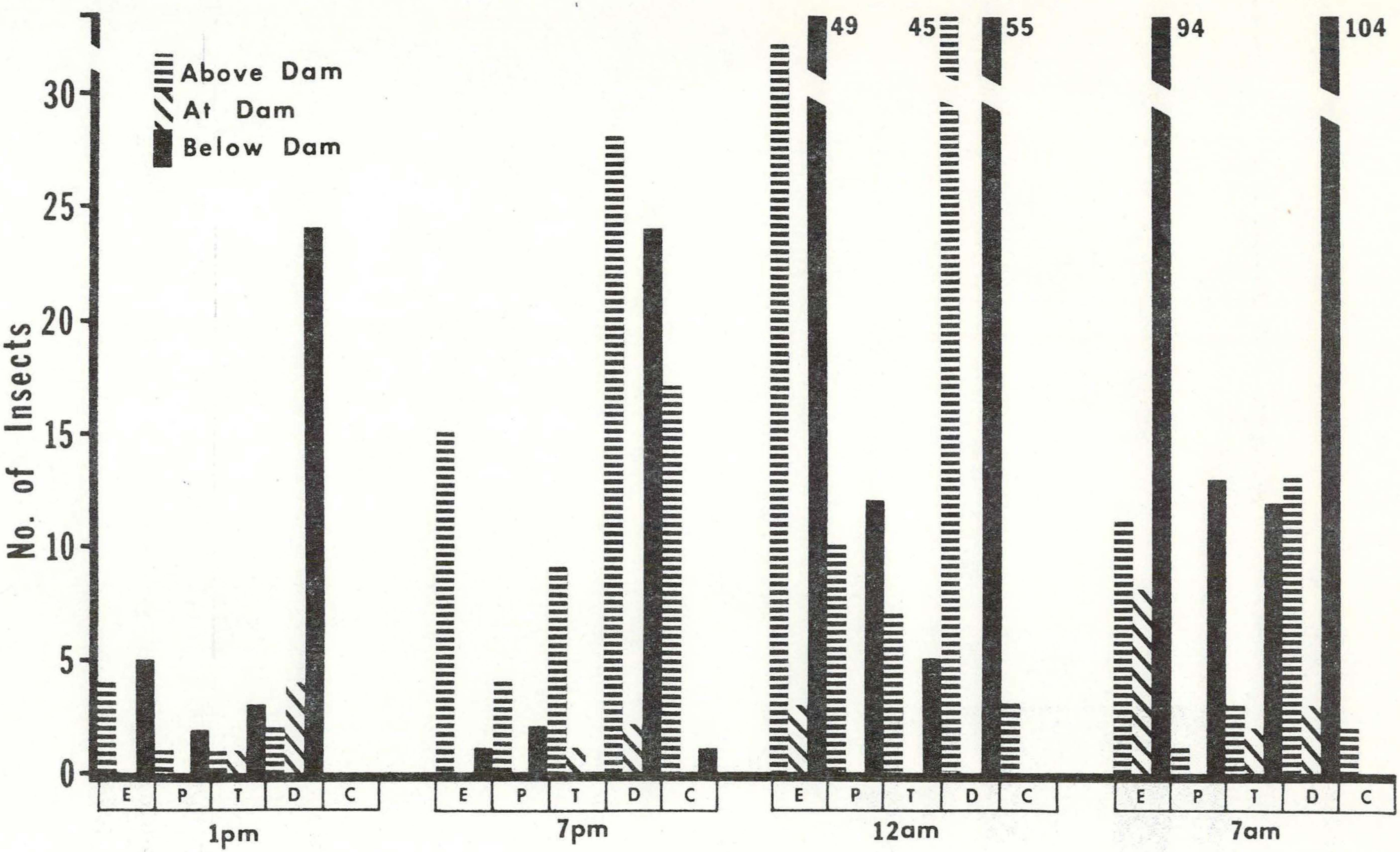
Appendix H. Ordinal insect drift for Control Creek, August 1975.
E = Ephemeroptera, P = Plecoptera, T = Trichoptera, D = Diptera, and C = Coleoptera



Appendix I. Ordinal insect drift for Eggers Creek, July 22, 1975.
E = Ephemeroptera, P = Plecoptera, T = Trichoptera, D = Diptera, and C = Coleoptera



Appendix J. Ordinal insect drift for Eggers Creek, August 13, 1975.
E = Ephemeroptera, P = Plecoptera, T = Trichoptera, D = Diptera, and C = Coleoptera



Appendix K. Ordinal insect drift at Eggers Creek, August 3, 1976.
E = Ephemeroptera, P = Plecoptera, T = Trichoptera, D = Diptera, and C = Coleoptera